METAL PROGRESS

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Metal Progress

February 1960 . . . Volume 77, No. 2

The cover shows a glowing hot rocket case being withdrawn from a controlled-atmosphere pit furnace after heat treating to 1900° F. The furnace is installed at the San Diego plant of Solar Aircraft Co., who made the picture especially for *Metal Progress*.

Technical News in Brief 65

Aluminum Gains in the Automotive Field . . . Titanium: New Applications and Revived Hope . . . New Steels: High-Nickel System and a Modified Alloy . . . Special Paints for Missile Heat . . . Cryogenic Gyroscope Has Long Life . . . High-Strength Pipe Solves Thermal Stress Problem . . . Beryllium Fasteners Offer Special Properties . . . Materials Progress in Nonmetallics for Bearings . . . More About Malleable Iron at Elevated Temperatures

Engineering Articles

Hydroforging . . . a New Fabricating Technique for Tubing, by M. L. Samuels 69

In centrifugally cast tubes of austenitic stainless steel, the coarse columnar structure can be broken up by a drastic hydraulic expansion from the inside. Annealing at 1950 to 2050° F. recrystallizes the cold worked metal (to form small equiaxed grains) and removes all residual stresses. Yield and tensile strengths rise 16 to 20% without loss in ductility. (G14b; SS, 4-60) *

Molecular Sieves in Atmosphere Control, by Herbert W. Westeren 75

These synthetic crystalline compounds, now being widely used in atmosphere generators, have a great affinity for water and other polar compounds, and can separate gases and liquids with remarkable selectivity according to their molecular sizes, polarity and carbon bond saturation. Specific applications are in gas drying, air drying, and gas separation. (J2k, W28a; NM-a)

A New Class of Lead-Base Alloys, by D. N. Williams, J. A. Houck and R. I. Jaffee 79

Experimental work indicates that dispersing a metal powder in lead improves its tensile properties. The new alloy is made by stirring powders of low solubility such as copper, nickel and cobalt into molten lead. (C5r, Q27a, R6g; Pb)

A Nitriding Steel That Age Hardens, by W. S. Mounce and A. J. Miller 91

This steel contains 5% Ni and 2% Al. It can be nitrided and hardened at the same time by an aging treatment in a nitriding atmosphere. The steel is expected to be useful for cams, gears, and shafts that need fatigue and wear resistance at elevated temperatures. (J27d, J28k; AY, *Ni, Al*)

High-Temperature Brazing Experiments, by R. R. Ruppender 95

Statistical analysis is suggested as a means of resolving discrepancies in results of similar fusion welding experiments. Details of a typical experiment illustrate the possibilities. (K8, S12)

A Modified Phase Diagram for Stainless Steel Weld Metals, by W. T. DeLong 98

A revised diagram for predicting the amount of ferrite in stainless steel welds accounts for the austenitizing effect of nitrogen in the welding rod. (N8, K9; SS)

How Boron Affects Corrosion of Type 304 Stainless, by J. W. Farrell and P. C. Rosenthal 101

Although boron improves the corrosion resistance of wrought Type 304 stainless, the protection it gives is not outstanding by present standards. (R2h, 2-60; SS, *B*)

Nondestructive Testing in a Steel Mill, by W. A. Black 104

A nondestructive method for testing steel products must be fast, cheap, automatic and, above all, discriminatory. Three unique devices, a seam depth indicator, a tube tester, and a portable ultrasonic unit, are described. (S13g, S13h; ST)

Grain Size in High-Alloy Hot Work Toolsteels, by R. F. Harvey 109

An isothermal method for outlining grains enables investigation of composition and heat treatment effects on high-alloy toolsteels. Tungsten inhibits grain growth, and reharden-ing treatments result in duplex structures. (M27c; TS)

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**The coding symbols refer to the ASM-SLA Metallurgical Literature Classification, International (Second) Edition, 1958*

How grid tray life was increased from 4 to 72 months

Electro-Alloys' knowledge of thermal fatigue extends service life 1700%

Figure 1 shows a grid tray used to move a solid cube of steel through a heat-treat furnace where side burners directed flame over the top of the tray, Figure 2. After 3-5 months' service, this tray would distort and fail, Figure 3. A photographic close-up of the failure is shown in Figure 4.

The user assumed the failure was due to inadequate pushing strength. With strengthened pushing ribs, the redesigned tray lasted only 2-3 months, half as long as the original design.

In view of this behavior, the user requested an Electro-Alloys design evaluation. The results are shown in Figure 5. *This new tray has a service life of 5-7 years!*

Pinpointing cause of thermal-fatigue failure

Electro-Alloys found that the *original tray* had been *overdesigned*. Extensive knowledge of the subtleties of thermal fatigue led to this conclusion.

Study of the furnace operation showed that the zones of heating and a heavy cooling concentration were the real causes of tray failure. They acted in this way:

On entry into the furnace, outside members of the tray heated more rapidly than inside members. As a result, expansion of these outside members was restricted by the cooler inside members. This set the stage for compression failure of outside members.

Farther in the furnace, inside members came up to temperature. But outside members had already forged in and were undersized. Now, expanding inside members subjected outside members to tensile stresses. This double reversal of stresses, compression then tension, during every cycle soon produced failure.

Any attempt to strengthen these outside members results in earlier failure because the increased mass leads to the metal fighting itself even more.

New design solves problem

The new design, Figure 5, called for raising the transverse ribs. This allowed the heated air to pass under the heavy die block. Through this simple change, it was possible to bring the die block to temperature more quickly and to eliminate the high temperature differential between outside and inside members of the tray.

The result is a 1700% increase in service from each tray.

Avoiding expensive thermal-fatigue pitfalls

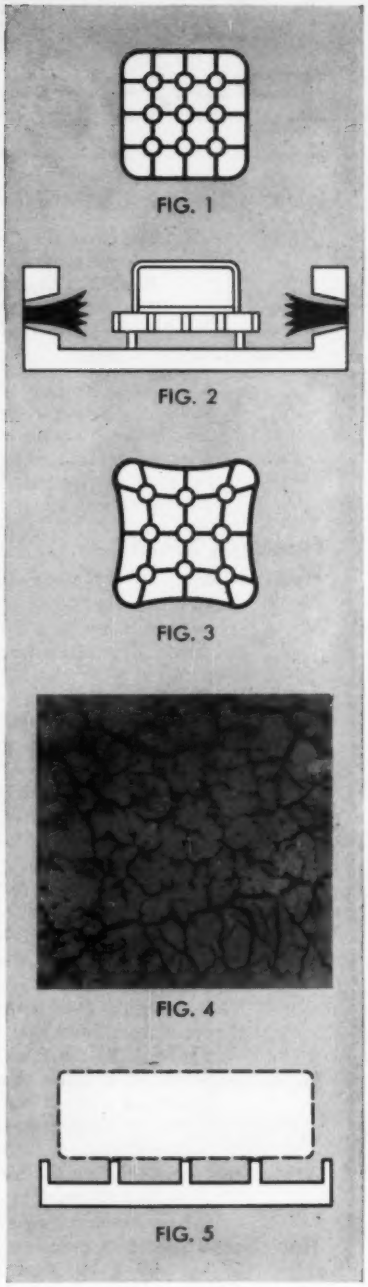
Users and designers of heat-resistant castings are vulnerable, generally, to two pitfalls that lead to losses in service life and operating economy:

a. Assuming that an alloy operating well at 2000°F. will work just as well in a different application whose maximum temperature is only 1700°F.

b. Too much faith in the calculation of applied stresses as the measure of the casting's ability to withstand service conditions. This is reflected by increasing the size or number of restricting members . . . braces, gussets and tie rods.

These pitfalls are a natural outgrowth of the lack of information on thermal fatigue . . . the cause of 90% of all failures of heat-resistant castings.

Electro-Alloys is recognized as the leading authority on thermal fatigue and high-alloy casting design. Hundreds of case histories — such as the one reported here — and the widely published test data emanating from the Research Laboratory at Mahwah, N. J., are evidence of this.



● *Most recent of these reports is "The Mechanism of Thermal Fatigue," by H. S. Avery. Copies of this study are available on request. Simply write to Electro-Alloys Division, 2012 Taylor Rd., Elyria, Ohio.*

American Brake Shoe Company

ELECTRO-ALLOYS DIVISION • Elyria, Ohio

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Metal Progress

Progress in Finishing

How to Determine Requirements for Rinse Water in Plating Processes, by H. W. Parker 82

Reduced costs in rinsing operations can be achieved by applying some basic principles. Here is an example. (L12e, L17)

Heat Treating Electroless Nickel Coatings, by K. T. Ziehlke, W. S. Dritt and C. H. Mahoney 84

Electroless nickel coatings containing 7 to 10.5% phosphorus can be heat treated to obtain various hardness and ductility combinations. The maximum hardness (1000 dph.) is independent of phosphorus content. (Q29, Q23p, 2-64, L28; *Ni*)

Cleaning Missile Tanks by Vapor Degreasing, Staff Report 88

Developed for cleaning the interior of liquid oxygen tanks for missiles, closed-system vapor degreasing is now catching on in the trucking industry. It does the job of removing asphalt, mineral, vegetable and animal oils, fats, most resins and plasticizers from tank walls quickly and economically. (L12j)

Special Report on Electroslag Welding

How Electroslag Welding Is Used in Russia, by Arthur B. Tesmen 118

Extensive work with electroslag welding in the U.S.S.R. has paid off. The process has gained a firm footing in industry and has proved economical and practical in the fabrication of heavy items with thick sections. (K6)

Approach to Electroslag Welding in the United States, Staff Report 123

Its economic advantage and efficiency already proven by practical experience in Europe and Russia, electroslag welding can expect quick acceptance in this country. (K6)

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Embrittlement by Hydrogen and Other Interstitials, by Alexander R. Troiano 112

Hydrogen embrittlement is sensitive to strain rate and temperature. Slow-strain-rate embrittlement, strain-aging embrittlement, and brittle delayed failure are all manifestations of the same basic phenomenon. (Q26, 2-60; ST, Ti, *H*)

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Constitution Diagram for Stainless Steel Weld Metal, by Anton L. Schaeffler; Revised Section by W. T. DeLong 100-B

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Metal Progress is published monthly by the American Society for Metals. Publication office Mt. Morris, Ill. Editorial and general offices Metals Park, Novelty, Ohio. Entered as second class matter at the Post Office in Mt. Morris, Ill. Vol. 77, No. 2, February 1960.

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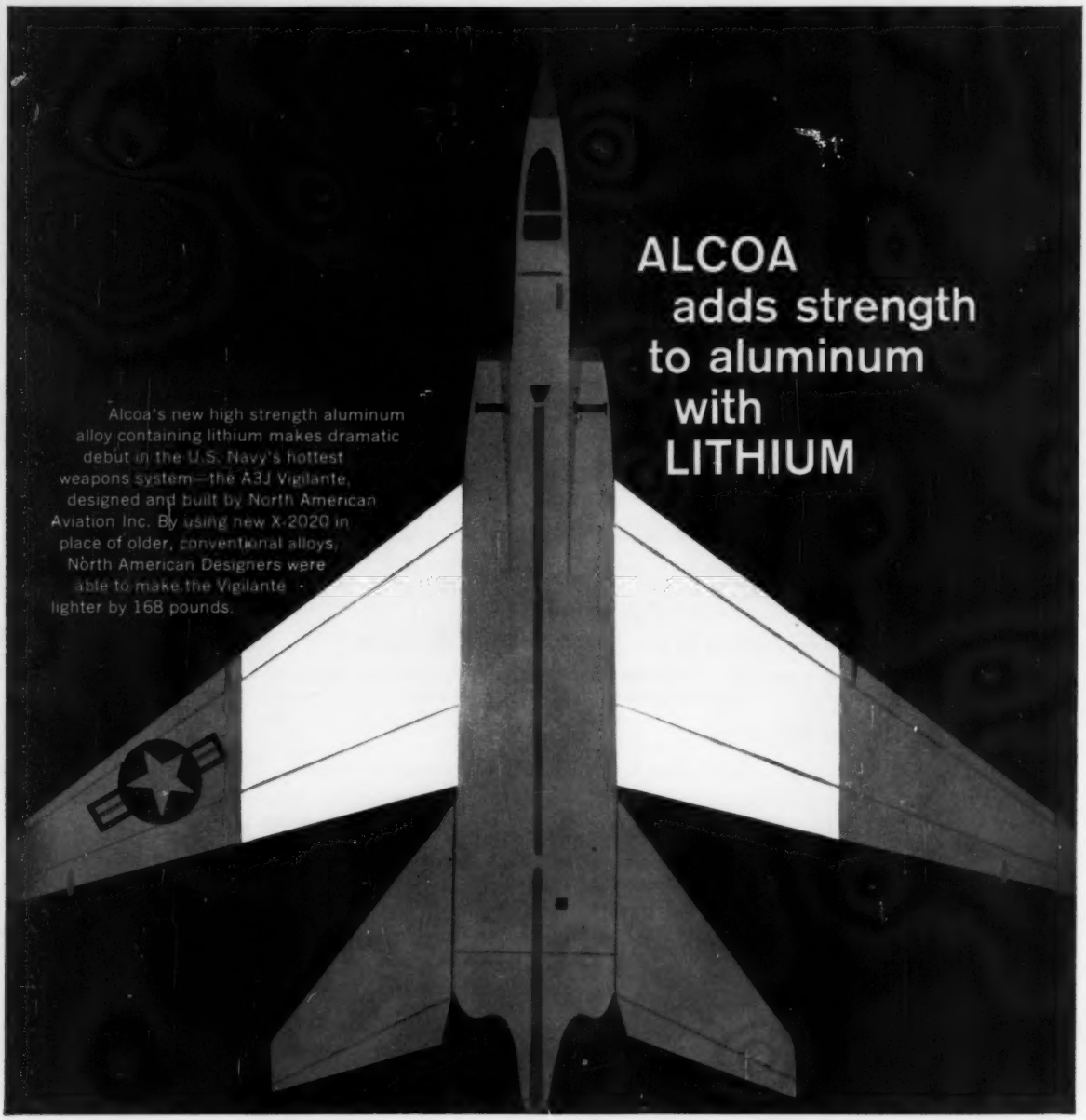
ALCOA
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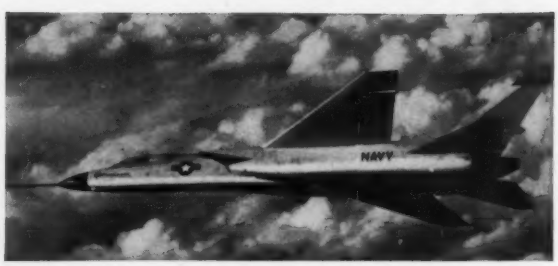
to aluminum
with
LITHIUM
Alcoa's new high strength aluminum alloy containing lithium makes dramatic debut in the U.S. Navy's hottest weapons system—the A3J Vigilante, designed and built by North American Aviation Inc. By using new X-2020 in place of older, conventional alloys, North American Designers were able to make the Vigilante lighter by 168 pounds.

By adding just one per cent or so of lithium as one of the important alloying components, Aluminum Company of America has boosted the thermal barrier of a high strength aluminum alloy more than 100 F . . . trimmed weight by a precious three per cent . . . raised modulus of elasticity eight per cent. New alloy X-2020 maintains strength up to 400 F, roughly equivalent to aircraft skin temperature at speeds of 1,600 mph.

A little lithium does things for this aluminum alloy . . . just as it does things for magnesium, lead, and most other non-ferrous metals. Add ten per cent lithium to magnesium, and you have the highest strength-to-weight ratio of any known system. Minute quantities of lithium, the lightest metal, added to lead, one of the heaviest, create an alloy that's tougher, stronger, and easier to form.

Three hundred references discussing the effect of lithium additions on non-ferrous metals have been compiled by Foote in a definitive bibliography, available on letterhead request. Write Foote Mineral Company, 424 Eighteen West Chelten Building, Philadelphia 44, Pa.



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PRESS BREAKS

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Word-Wise – Being an editor, the Editor-in-Chief is more-than-usually interested in using words in their correct meanings – "semantics" is the $64 word for it. Meanings can get badly turned around, word-wise (to use a hated cliché). For example, we Americans call our representative government a democracy while the Russians use the same word for their tyranny. Only the other day I was in a committee meeting and one member was talking about "designing" and "designers" of metallic parts, and I was picturing to myself all the time a chap bending over a drawing board, when suddenly I discovered the speaker was talking about choice of metallic alloy, its fabrication and heat treatment to perform certain services – a matter I would call "engineering". Over and over again, also, teachers in American colleges are caught using "engineering" and "science" as synonyms. Finally is the regrettable trend toward lumping together everything used by mankind under the heading of "materials", a matter which reached an extreme in a recent "Guide to the Scope of the Engineering Materials Program of the Atomic Energy Commission". When you turn to the pages describing "Metallurgical Equipment and Processes", you do not find mention of, say, cast steel for roll housings, as you might expect from the book's title of "Materials", but: "Includes equipment for fabricating graphite, metals, compacts and ceramics." Since when has "equipment" started to mean "materials"?

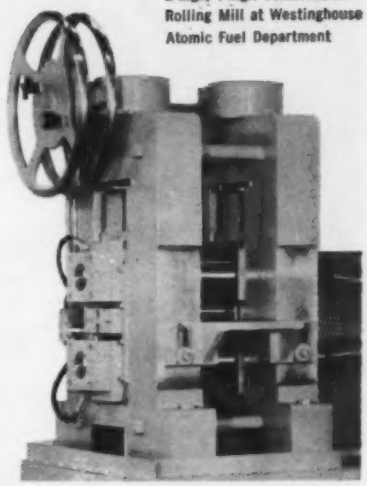
Press Breaks in January carried a comment that secrecy in technical matters is likely to harm the hider more than it helps him. An extension to that remark would be that it also harms his industry, his nation and civilization itself. This is emphasized in M. Postan's chapter entitled "Why Was Science Backward in the Middle Ages" in the very readable "Short History of Science" (a Doubleday paperback). Professor Postan blames the stagnation in the arts and industries on the regulations adopted by most towns to fix prices and protect individual masters from competition; the technical methods in existence were fixed, frozen. "To take an example, the machine for throwing silk invented in 1272 by Borghesano of Bologna was not to be known outside Bologna until 1538." An exception was that of building, which developed very rapidly. "Medieval building was in the hands of masons who were 'free', free in the sense that they were migratory laborers seldom subject to supervision and technical control by town governments."

Editors Thum and Gray were recently at Oak Ridge National Laboratory attending a meeting of the U. S. Atomic Energy Commission's Advisory Committee on Industrial Information. Its Technical Information Services, centered in Oak Ridge, have on file about 100,000 scientific, engineering and technical reports generated in A.E.C. operations. Robert Shannon, in charge, says that the commonest letter he receives starts out "Where should I go in Washington to see your paper on . . .", but as a matter of fact, there are 90 "depository libraries" scattered throughout the states; at any of them anyone can get as much current information as he could in Washington or in Oak Ridge. Use the depository libraries!

THE EDITORS

LOMA

1½" & 6" x 8" Heavy Duty 2-high/4-high Combination Rolling Mill at Westinghouse Atomic Fuel Department



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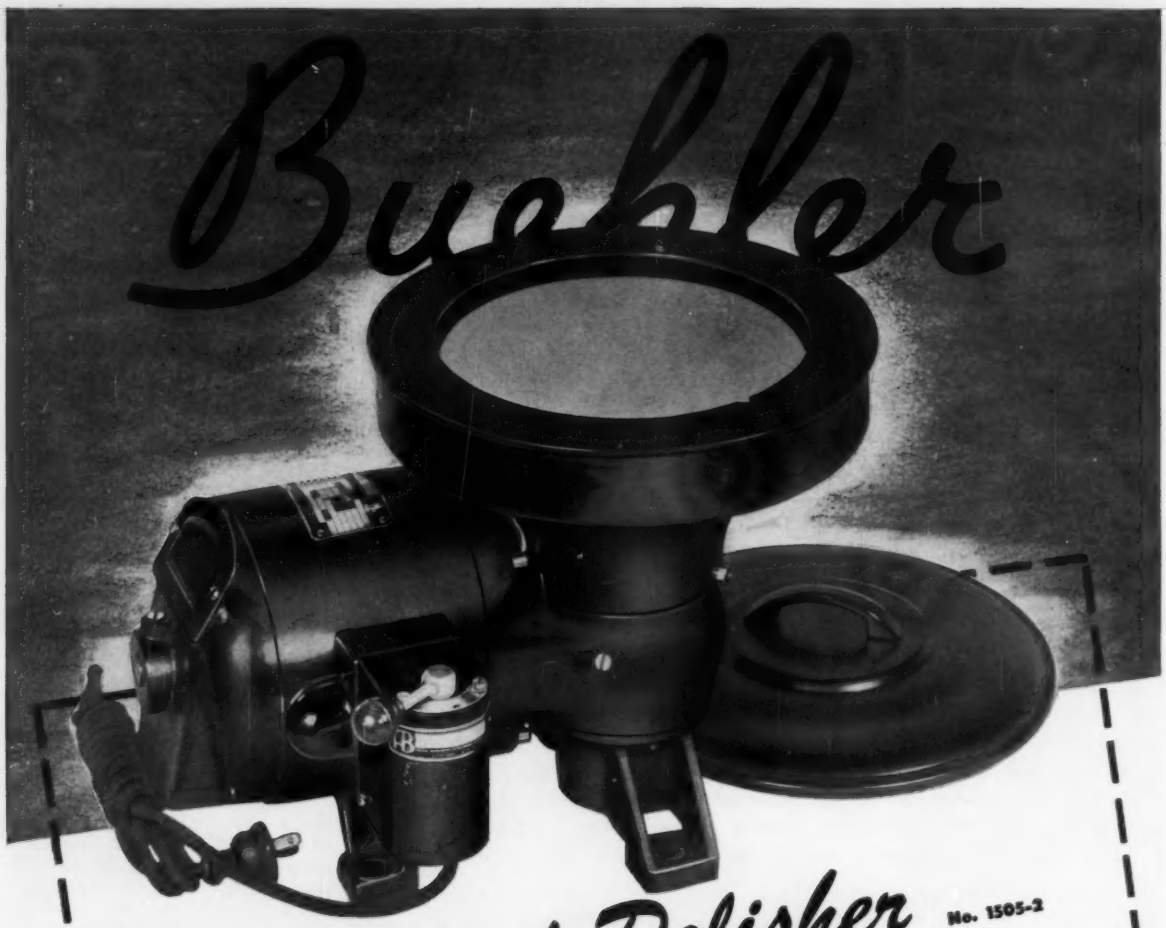

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Metal Progress

PUBLISHED BY AMERICAN SOCIETY FOR METALS
METALS PARK, NOVELTY, OHIO

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METAL PROGRESS is published monthly by the AMERICAN SOCIETY FOR METALS. Printed by Kable Printing Co., Mt. Morris, Ill.

Subscription $9.00 a year in U. S. and Canada; foreign $15.00. Single copies $1.50; special issues $3.00. Requests for change in address should include *old* address of the subscriber; missing numbers due to "change of address" cannot be replaced. Claims for nondelivery must be made within 60 days of issue. No claims allowed to overseas subscribers.

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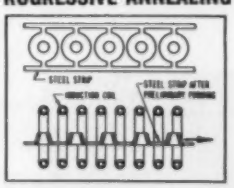
TYPICAL INDUCTION HEATING APPLICATIONS

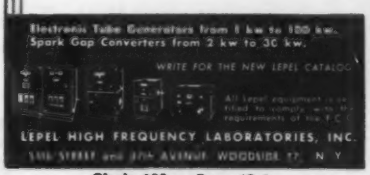
PLASTIC COATING OF TOOL HANDLES

A production line operation for coating handles of tools at Whitney Metal Tool Co., Rockford, Ill. uses induction heating with excellent results. The handles only are heated by induction to the desired temperature then dipped into a vinyl chloride base coating material for a short period depending upon the thickness of coating desired. The plastic coating formed on the handles is then cured by immersion in a carbo-wax bath.

FORMING OF METAL STRIP FACILITATED BY PROGRESSIVE ANNEALING



Metal forming operations which require intermediate anneals to restore ductility can be facilitated by induction annealing the strip progressively. Diagram illustrates this procedure for partially formed thin austenitic stainless steel strip. The induction annealing operation is scheduled in the production line between two press operations. Metal strip and wire of other materials are also induction annealed in this manner.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Spark Gap Converters from 2 kw to 30 kw.
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LEPEL HIGH FREQUENCY LABORATORIES, INC.

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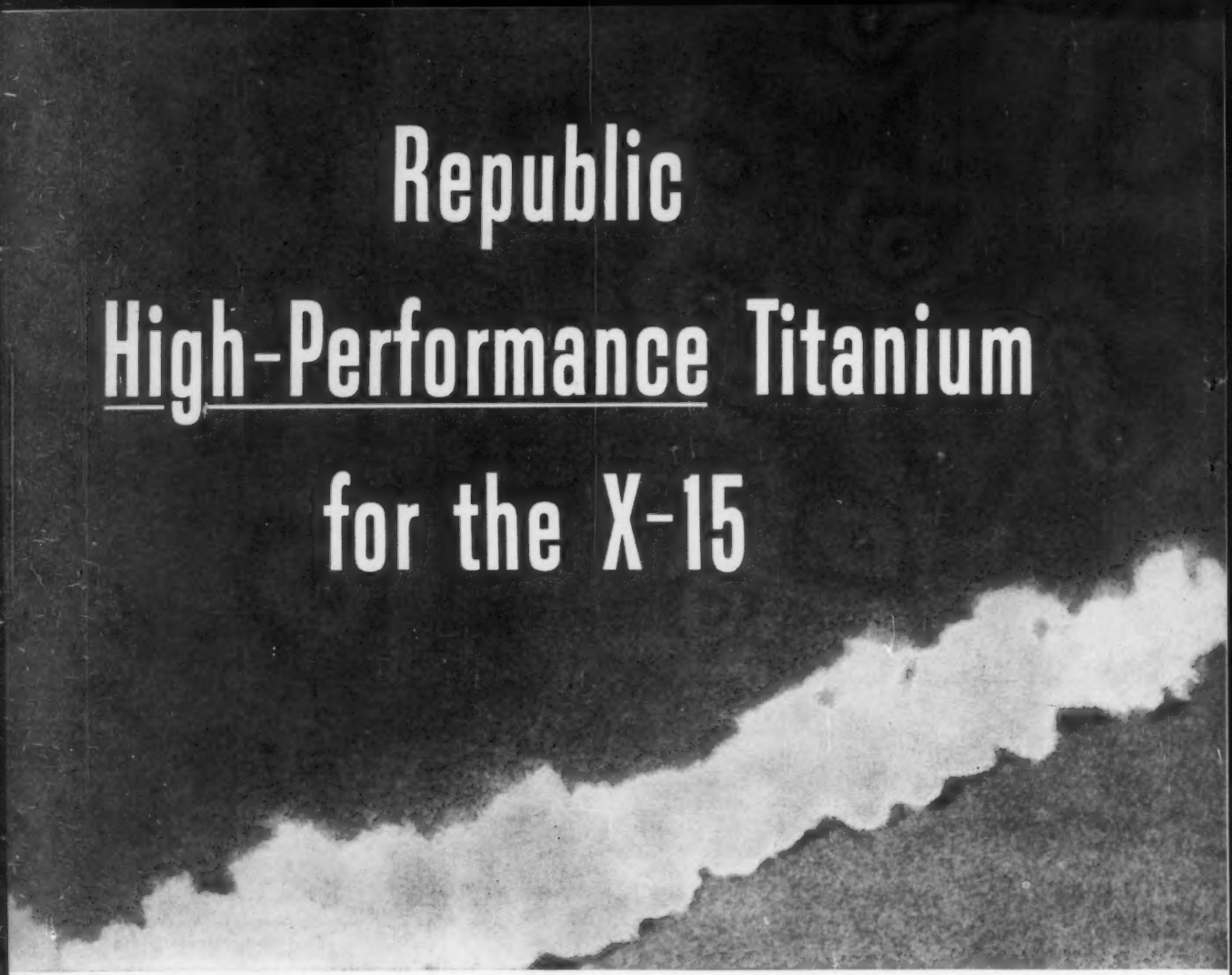
Republic High-Performance Titanium for the X-15



In a number of highly stressed components subject to extreme high and low temperature fluctuations, *high-performance* titanium in the X-15 Research Vehicle will help take man higher and faster than he has ever been before.

Republic Steel—a leading supplier of titanium, and the nation's largest producer of stainless and alloy steels—is supplying North American Aviation with Type 110A titanium for internal structures on the X-15 project.

Let us help you utilize *high-performance* metals to increase strength, resist heat, or trim weight. Write Republic Steel, Dept. MP-8591, 1441 Republic Building, Cleveland 1, Ohio.
Please indicate if you would like a titanium metallurgist to call.

REPUBLIC STEEL *Where Steels are*

FIRST POWERED FLIGHT of the North American X-15 came on September 21, 1959, over Edwards AFB. Carrying a full load of fuel (note frost from liquid oxygen at top and bottom of fuselage), the X-15 flew under power for 3.5 minutes at speeds in excess of Mach 2.

REPUBLIC STAINLESS STEEL is used in leading edges of the Convair 880's vertical fin and horizontal stabilizer where anti-icing is accomplished through electrical heating of the metal. Use of Republic ENDURO® Stainless Steel increases strength and heat-resistance, permits thinner, lighter gages. Types 301 and 302 are readily formed into desired shapes by cold forming, drawing, and bending operations.

REPUBLIC'S NEW HIGH STRENGTH POWDER, TYPE HS6460

is ideal for sinterings of highly stressed components. Provides minimum tensile strength of 60,000 psi at 6.4 density as sintered . . . 100,000 psi after heat treatment. Maximum of .004% shrinkage from die size at 6.4 density. Available in quantities up to and including 12 tons or multiples. Can be used with existing operating equipment.

REPUBLIC VACUUM-MELTED ALLOYS heat treated to tensile strength levels of 270,000 to 300,000 psi are produced in fifteen thousand-pound heats for missiles such as the Minuteman. Vacuum arc process minimizes segregation and center porosity. Nonmetallic inclusions are reduced in number and size. Transverse ductility at high strength levels is also greatly improved.

Made to Meet the Challenge of Acceleration

REPUBLIC STEEL

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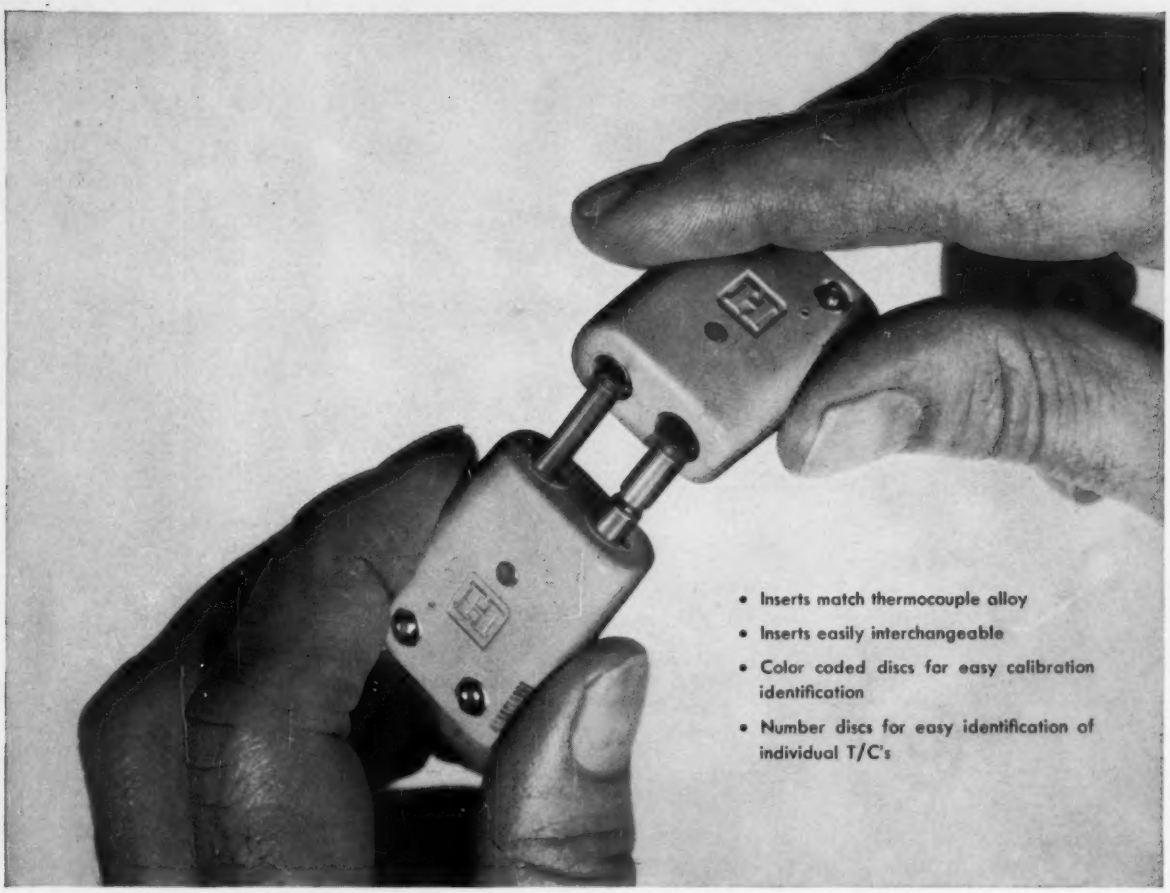
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For accurate, swift, and foolproof connection of thermocouples to extension wire

New *QuiK-Konnect* plug and jack bodies give fast, easy, and foolproof extension wire connections in plant, laboratory or test cell installations.

Inserts have different diameter positive and negative poles, for foolproof connection . . . are extremely easy to remove for field calibration change or replacement. Various tube adapters are available to protect small-diameter thermocouples, and cable clamps can be supplied to protect extension wires from fraying or tearing.

The *QuiK-Konnect* line, in addition to plugs and jacks, includes:

1. Single-jack panel that fits ¾-in. knockout.
2. 4-point jack panel that fits standard electrical outlet box.
3. Multiple jack strips.
4. Custom-built multiple jack panels.
5. *QuiK-Kords** for patch programming multiple jack panels.

You can get complete details from your nearby Honeywell field engineer. Call him today . . . he's as near as your phone.

MINNEAPOLIS-HONEYWELL, 21 Penn St., Fall River, Mass.

*Trademarks

75th YEAR — PIONEERING THE FUTURE

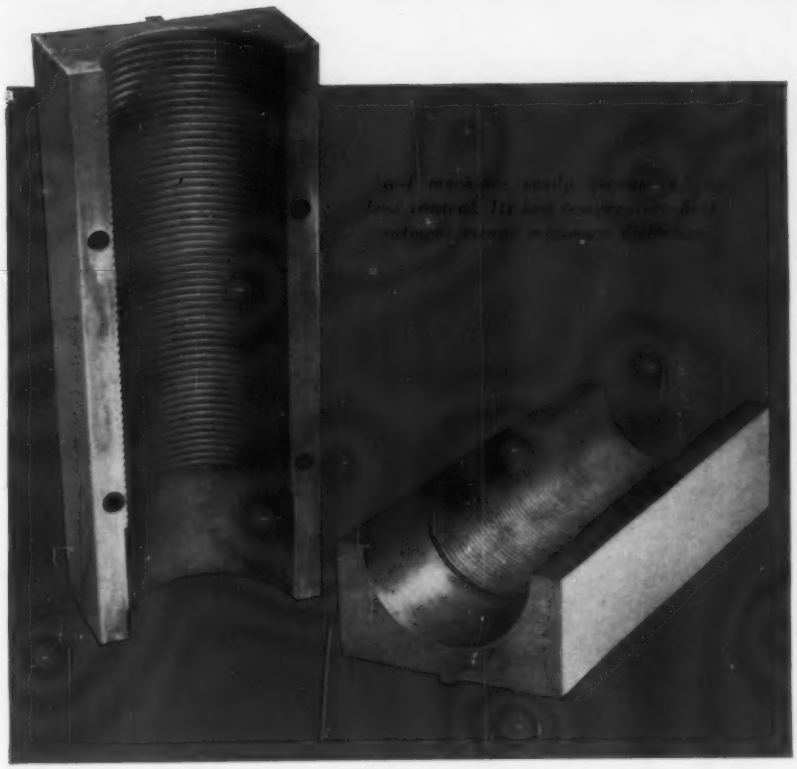
Honeywell

First in Control — SINCE 1885

Circle 464 on Page 48-A

Tool Steel Topics

BETHLEHEM STEEL



Another Report on AIR-4 TOOL STEEL:

"These clamping bars machined like a dream, and distortion was kept to a minimum."

The clamping bars above, of Bethlehem Air-4 tool steel, were made by Miller Tool and Die Company, Gloucester, N.J. John J. Nesbitt, Inc., Philadelphia, uses them for holding and expanding metal tubing. The dies, hardened to Rockwell C 57-58, were each machined from a piece of Air-4 1¾ in. thick, 3½ in. wide, and about 8 in. long. The over-all tolerances were plus or minus .002 in.

Easy to Machine, Low Distortion

According to our local tool steel distributor, Horace T. Potts Company, the customer reported that the machinability was "like a dream." And they were also delighted with the lack of distortion during heat-treatment—"best distortion-resisting grade we've ever used for this type of die."

Hardens in Air at 1550F

Air-4 is our new free-machining medium-alloy tool steel. It hardens in air at low temperature—about 1550F. It has excellent free-machining characteristics because of its addition of lead. Air-4 also has superior wear-resistance, high toughness, and deep-hardening properties, making it ideal for long tool life.

If you would like to have additional information about Air-4, get in touch with your Bethlehem tool steel distributor. Better still, order a trial bar and put it to work in your shop.

Circle 465 on Page 48-A

BETHLEHEM TOOL STEEL ENGINEER SAYS:

The Direction of Grinding Marks Affects the Life of Tools

It might be well to take a good look at your tool-grinding practice, because it has been proved time and again that the direction of grinding marks has a direct bearing upon tool life. This is especially true with such tools as deep-drawing dies, and punches that have a moving contact with metals under high pressures.

No matter how fine or smooth the surface finish of ground tools may appear to be, don't be fooled—it actually has a saw-tooth contour. Material which moves parallel to the grinding marks shows much less tendency to "pick up," or adhere, than material moving across the grinding marks. But this "pick up" of material can't be permitted on such tools as drawing dies, where it's advantageous to grind in the same direction as the material moves. On some types of tools this kind of grinding is difficult, but the longer tool life justifies the effort. Punches which are ground longitudinally last much longer than those ground circumferentially, the most common method. Here also, longitudinal grinding is inconvenient, but worthwhile.

Although the direction of grinding on tools isn't given much thought in the average shop, it is often a big factor in getting the best possible tool life.

Send for TOOL STEEL LITERATURE

If you would like to receive booklets on Bethlehem tool steels, indicate your choice on this coupon, and mail to Room 1044, Publications Department, Bethlehem Steel Company, Bethlehem, Pa.

- ☐ Hot Work
- ☐ High Speed
- ☐ Carbon and Carbon-Vanadium
- ☐ Shock Resisting
- ☐ Hollow Bar
- ☐ Oil and Air Hardening
- ☐ Special Purpose
- ☐ Lehigh H (High Carbon, High Chrome)
- ☐ Bearcat
- ☐ Tool Steel Selector

THE LITHIUM REACTOR

PERTINENT INFORMATION ON LITHIUM CHEMISTRY AND METALLURGY

L C A Acquires Fulton-Irgon

The Fulton-Irgon Corporation, a pioneer in propellants and rockets, was acquired recently by Lithium Corporation of America. This purchase will provide L C A with research and production abilities in the broad field of missiles, rockets and advanced aircraft systems. Continuing operation as the Fulton-Irgon Division, the new acquisition will enable L C A to provide better service to its present and potential customers since lithium chemicals and lithium alloys are already under active investigation in this field.

LITHIUM IN BRIEF

New developments involving lithium are constantly appearing in the literature. Each month some will be reported here. For further information, write our Sales Service Department.

Lithium, included in alloys for vapor coating with silver, prevents dark residue formation on vaporization filament. (1404).

Lithium is added to a self-flowing air-proof brazing alloy containing boron and based upon copper, nickel and palladium. (1238-9).

Old Art Serves Modern Industry

High conductivity copper, increasingly in demand by modern industry, is purified by a method pioneered almost 30 years ago by Osborg and Smith. These investigators demonstrated conclusively that lithium not only deoxidized ferrous and non-ferrous melts, but also performed a scavenging action and acted as a grain refiner of the cast metal.

To meet the needs of foundry men, L C A developed the "Lithium Cartridge," a cylinder of pure lithium metal encased in 99.9% copper, and hermetically sealed against deterioration. Because these new cartridges did not require material changes in ordinary foundry practice, nor specialized equipment for effective use, they won rapid acceptance wherever gas porosity, inclusions and poor grain structure in castings were a problem.

Lithium, properly applied in quantities of less than one part in ten thousand of melt, eliminates most of these imperfections. The smallest cartridge will treat 50 lbs of copper and the largest, 2400 lbs.

The two other sized cartridges make possible treatment of melts of all weights.

Aluminum Alloy Containing Lithium—New Advance for Supersonic Aircraft

Higher Thermal Barrier, Lighter Weight, Improved Modulus of Elasticity Characterize New Alloy

An exciting, high strength aluminum alloy containing lithium, called X2020, has been developed recently by research engineers at Aluminum Company of America. This new metal will maintain its high strength at temperatures up to 400 degrees F, surpassing the thermal barrier of former aluminum aircraft alloys of similar strength by about 100 degrees F. Jet-propelled ships traveling 1600 mph at operating altitudes develop "skin" temperatures of approximately 350 degrees F. Conventional aluminum aircraft alloys begin to lose their physical properties in the 250-350 degree F range encountered at speeds below 1300 mph. Presently under consideration for the Vigilante aircraft, X2020 is also expected to find applications in future forms of the B58 and other missiles and aircraft which fly at speeds which are prohibitive to the use of conventional aluminum alloys.

Another important feature of X2020 which makes it especially applicable for aircraft usage is its lighter weight.

ANNOUNCEMENT

The uses of lithium in chemistry and metallurgy are expanding at a rapid rate. To bring you the news of the latest developments, Lithium Corporation of America will publish a new series of technical news bulletins of which this is the first. Additional copies of the LITHIUM REACTOR will be supplied regularly by mail to readers upon request.

For additional information on the items appearing in the LITHIUM REACTOR, address inquiries to: LITHIUM CORPORATION OF AMERICA, INC., Sales Service Department, Title Insurance Building, Minneapolis 1, Minn.

More than 3 per cent lighter than previously available aluminum alloys and lower in cost than commonly used high-temperature resistant metals, this new alloy will account for substantial reductions in total aircraft weight and cost. Modulus of elasticity, of prime importance in aircraft design, is improved 8 per cent by virtue of the lithium content of this material.

According to Alcoa, all mill products of the new alloy lend themselves to standard fabrication techniques employed by the aircraft industry. Presently available only in experimental quantities, X2020 is expected to be in full production by the time performance properties have been fully determined.

LITHIUM CORPORATION OF AMERICA BUILDING NEW LABORATORIES AT BESSEMER CITY

L C A's Bessemer City plant where centralized research facilities for the company are under construction. The new laboratories, expected to be completed early next summer, will house greatly expanded facilities and staff.

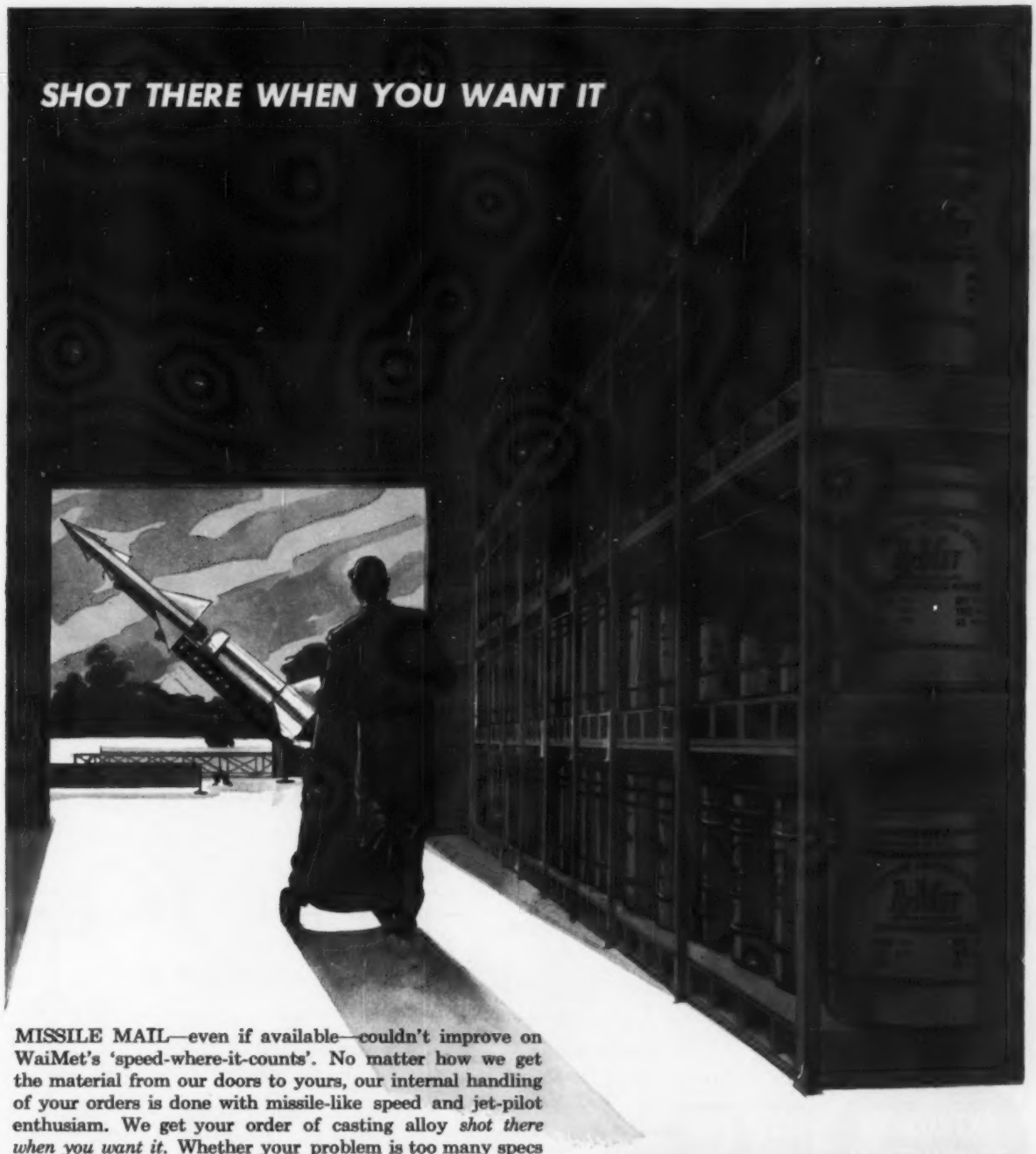
LITHIUM CORPORATION OF AMERICA, INC.

SALES SERVICE DEPARTMENT • TITLE INSURANCE BUILDING • MINNEAPOLIS 1, MINN.

NEW YORK 17, N. Y. • CLEVELAND 14, OHIO • CHICAGO, 1, ILL. • LOS ANGELES 36, CALIF. • BESSEMER CITY, N.C.

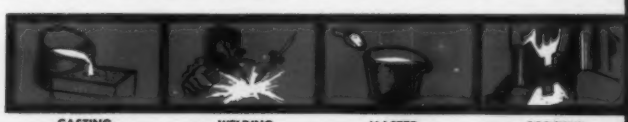
Circle 466 on Page 48-A

SHOT THERE WHEN YOU WANT IT



MISSILE MAIL—even if available—couldn't improve on WaiMet's 'speed-where-it-counts'. No matter how we get the material from our doors to yours, our internal handling of your orders is done with missile-like speed and jet-pilot enthusiam. We get your order of casting alloy *shot there when you want it.* Whether your problem is too many specs (try our *Rx MET-U* alloys) or better properties in tough alloys (read our reports on 17-4PH and WI-52) or just regular on-time shipments of castings alloys, call on WaiMet, leaders in special alloys.

AND NOW, we're doing new and interesting things in special alloy forging billets and master alloys.



WAIMET ALLOYS CO.

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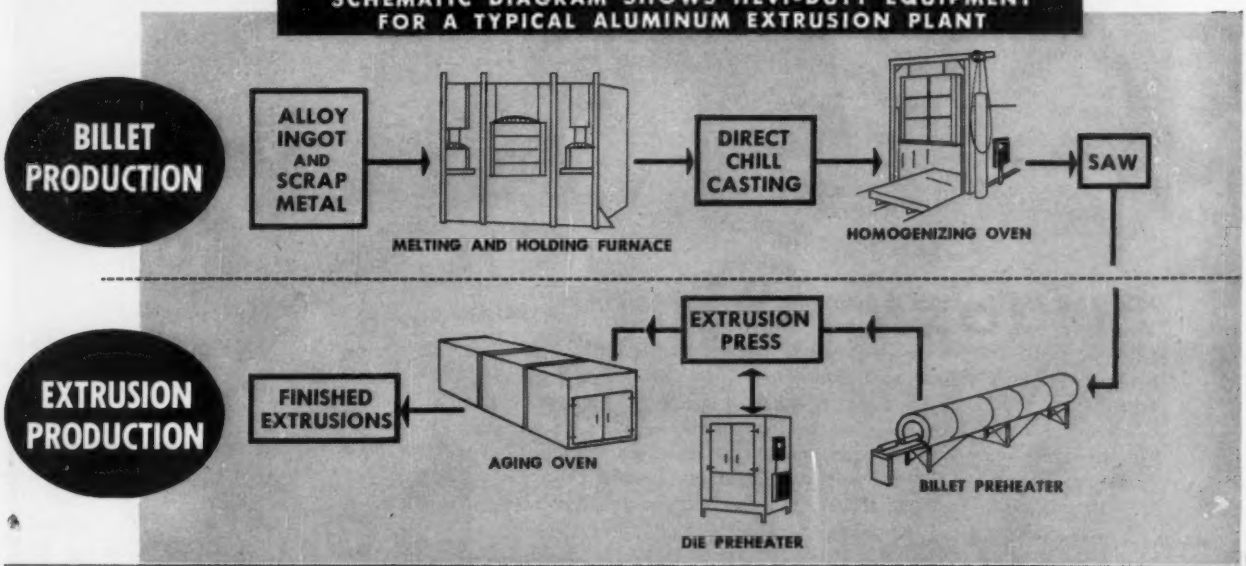
TOOL STEELS • STAINLESS STEELS
SUPERALLOYS • VACUUM-MELTED ALLOYS

Circle 598 on Page 48-A

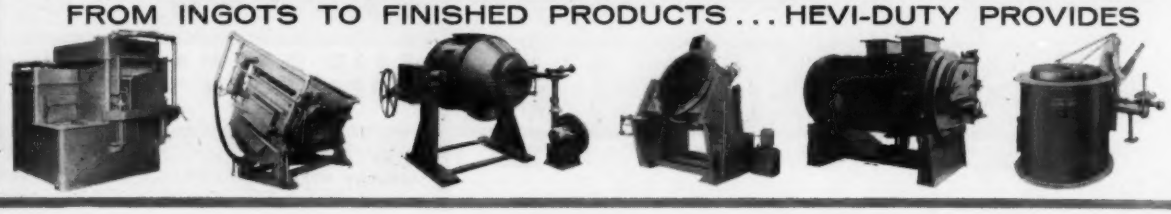
HEVI-DUTY your prime source for

MELTING AND HOLDING FURNACE—*These Hevi-Duty reverberatory furnaces provide maximum efficiencies for melting and holding aluminum. Available in capacities to 60,000 pounds, this type of furnace can be used for smelting, billet casting, die casting, permanent mold work, and other foundry melting.*

SCHEMATIC DIAGRAM SHOWS HEVI-DUTY EQUIPMENT FOR A TYPICAL ALUMINUM EXTRUSION PLANT



FROM INGOTS TO FINISHED PRODUCTS . . . HEVI-DUTY PROVIDES



quality furnaces and ovens for aluminum

Melting, holding, and heat-treating furnaces . . . billet preheaters, homogenizing and aging ovens . . . engineered to meet your production requirements.

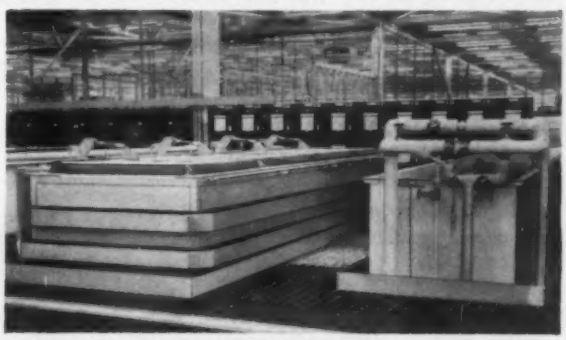
Whatever your heating requirements for processing aluminum, you can depend on Hevi-Duty standard and specially-engineered furnaces and ovens to do the job efficiently and economically. Throughout the aluminum industry, Hevi-Duty equipment serves in practically every phase of heat-treatment and melting.

For example: In a typical aluminum extrusion plant, as illustrated in the schematic diagram, Hevi-Duty equipment plays a major role. Fuel-fired reverberatory furnaces provide fast, controlled heat for melting and holding metal for billet casting. Hevi-Duty homogenizing ovens, either fuel-fired or electrically heated, assure high quality aluminum billets. Hevi-Duty preheat ovens are used to heat the billets in preparation for extruding. Hevi-Duty tray type ovens are used to preheat extrusion dies. Aging of the extruded aluminum shapes is accomplished in Hevi-Duty ovens at temperatures to 400° F.

What's more, Hevi-Duty offers a complete range of electric and fuel-fired heat-treating furnaces for rapid solution treatment and aging of aluminum and aluminum alloys at elevated temperatures.

The application of heat to aluminum is a specialty at Hevi-Duty. Our engineers can help you boost your product output at lower cost. Contact Hevi-Duty first for *all* furnaces and ovens required for processing aluminum.

HOMOGENIZING OVEN—*Homogenizing of aluminum logs is accomplished in this Hevi-Duty car-bottom oven at temperatures of approximately 1000° F. Finished extrusions consequently have superior physical properties.*



SOLUTION TREATMENT AND AGING—*Typical Hevi-Duty immersed electrode salt bath furnace used for solution heat-treating of large aluminum aircraft sections. Furnace illustrated has a pot 20 feet long, 4½ feet wide, and 6 feet deep.*

ASK HEVI-DUTY

For more information on the complete range of furnaces and ovens for aluminum processing, write for bulletins 653, 591, and 159.

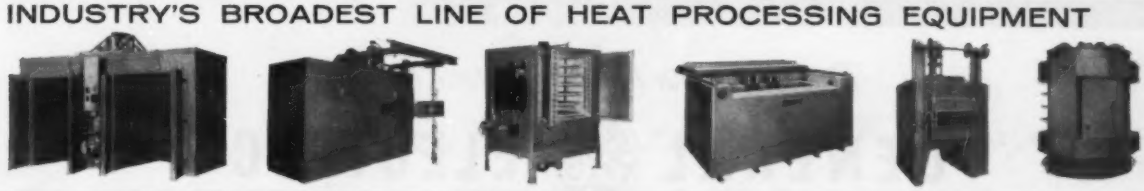
HEVI-DUTY

A DIVISION OF BASIC PRODUCTS CORPORATION

HEVI-DUTY ELECTRIC COMPANY, MILWAUKEE 1, WISCONSIN

Industrial Furnaces and Ovens, Electric and Fuel • Laboratory Furnaces • Dry Type Transformers • Constant Current Regulators

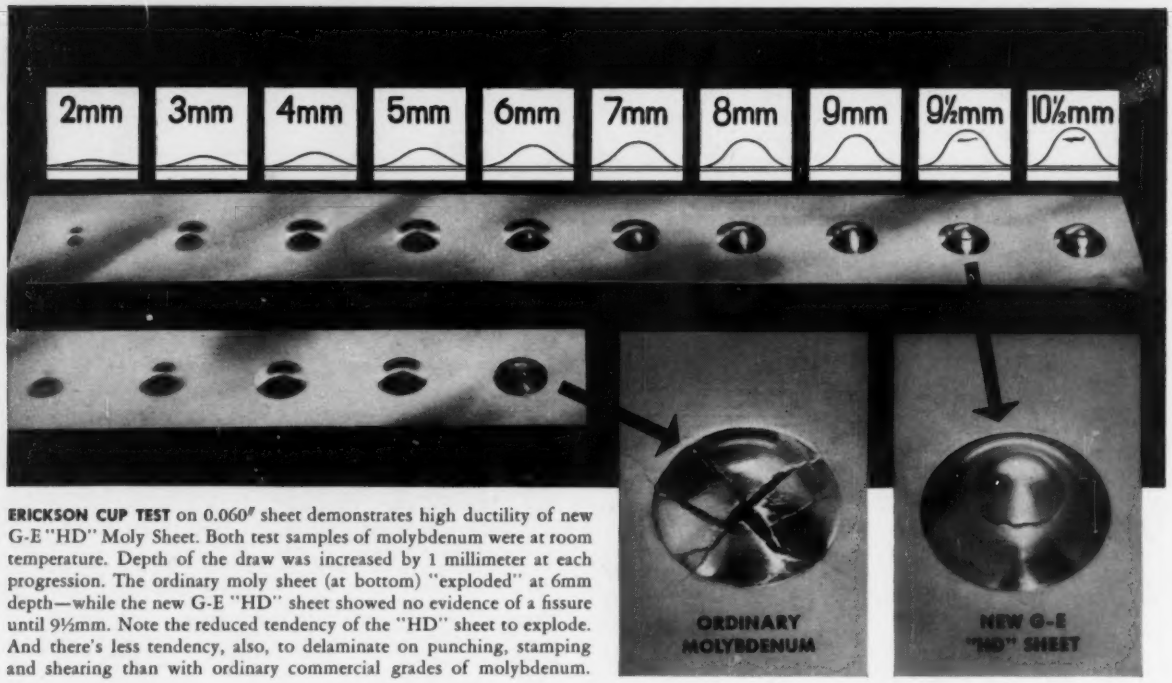
INDUSTRY'S BROADEST LINE OF HEAT PROCESSING EQUIPMENT



Circle 467 on Page 48-A

Now you can deep draw and bend molybdenum sheet at room temperature!

. . . with General Electric's new High-Ductility (HD) Molybdenum Sheet



ERICKSON CUP TEST on 0.060″ sheet demonstrates high ductility of new G-E "HD" Moly Sheet. Both test samples of molybdenum were at room temperature. Depth of the draw was increased by 1 millimeter at each progression. The ordinary moly sheet (at bottom) "exploded" at 6mm depth—while the new G-E "HD" sheet showed no evidence of a fissure until 9½mm. Note the reduced tendency of the "HD" sheet to explode. And there's less tendency, also, to delaminate on punching, stamping and shearing than with ordinary commercial grades of molybdenum.

DRAW IT! FORM IT! PUNCH IT!—all without preheating! General Electric's new "HD" Moly Sheet can take it—and you can do all these operations in thicknesses previously impossible . . . or requiring up to 1000°F preheating. Even in cases where small amounts of heat may be needed, it's always less than with ordinary molybdenum sheet.

TIME SAVER, MONEY SAVER! The improved ductility of General Electric's new "HD" Molybdenum Sheet is of particular significance in sheet thicknesses of 0.020″ to 0.125″—as used in electronic tubes and semiconductor diodes, rectifiers and similar products. It has a high melting point (2622°C, 4752°F), low vapor pressure, and excellent strength at elevated temperatures. So it will be of great value to any company using refractory metals.

PLAN ON G-E "HD" SHEET Available in commercial quantities, so there's no better time than right now to get all the facts about this new kind of molybdenum. Write: General Electric Co., Lamp Metals and Components Dept. MP-20, 21800 Tungsten Road, Cleveland 17, Ohio.

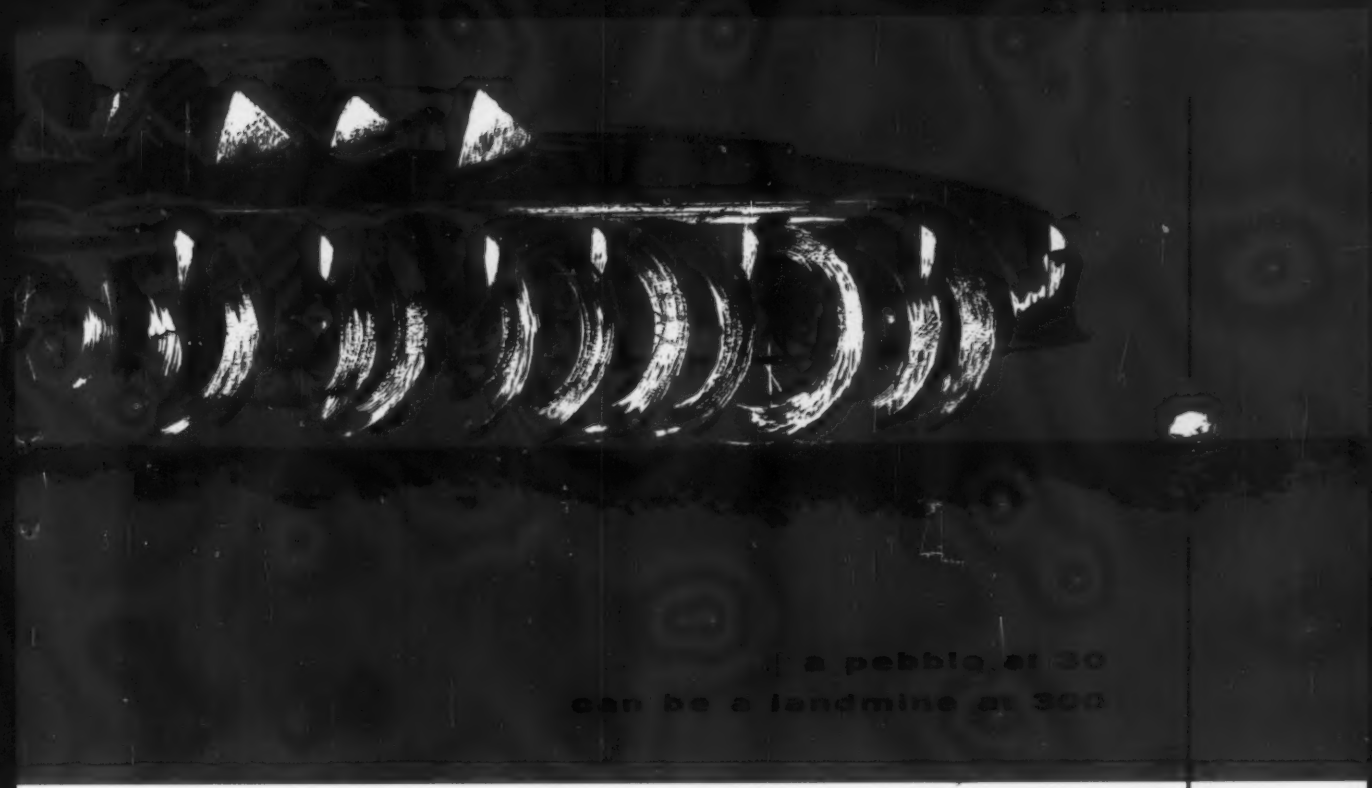
BENDS WITHOUT CRACKING . . . EVEN WITH NO PREHEATING!

Ordinary 0.060″ thick molybdenum broke at a 20° bend (see photo at left). The G-E "HD" sheet of same thickness shows no sign of cracking at 90°. Actually this new G-E Moly Sheet is so ductile you can bend it up to 180° without damage!

Progress Is Our Most Important Product

GENERAL ELECTRIC

Circle 468 on Page 48-A



the harder you drive for
super speed production
the more you need safe-
guards offered you in...

brass

copper

aluminum

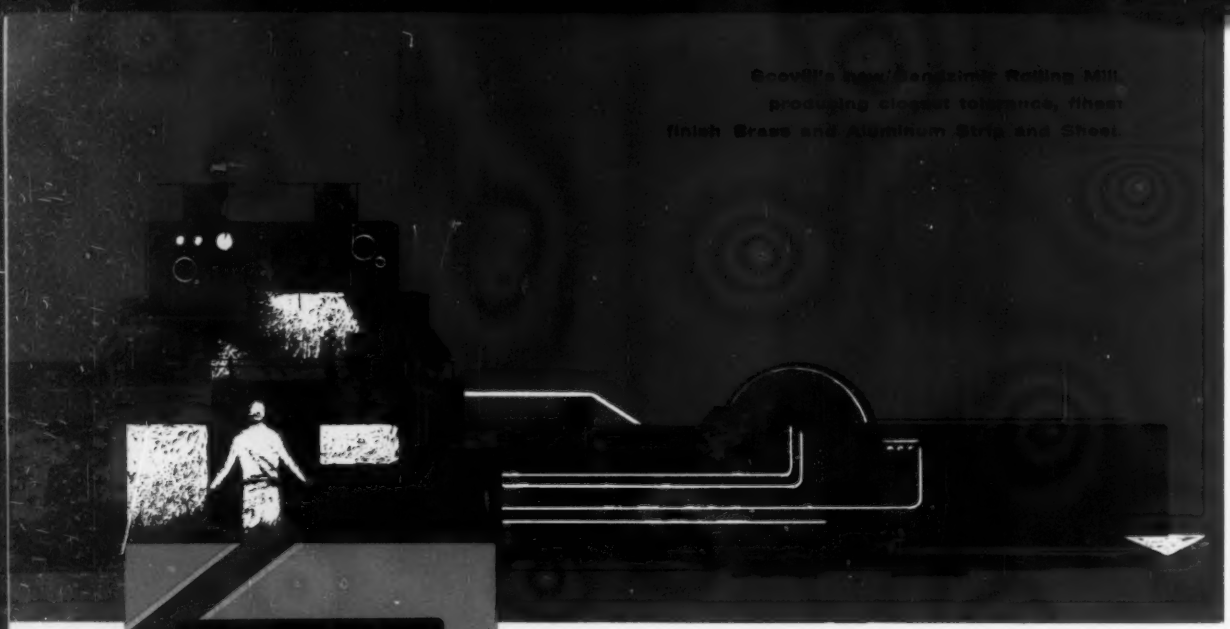
MILL PRODUCTS

MADE IN USA

. . . and made better to bring out the ***BEST*** *in your products*

Scovill Manufacturing Company, Mill Products Division, 99 Mill St., Waterbury 20, Conn. Phone PLaza 4-1171

3SC60



SCOVILL®

features
to help you take
full advantage
of today's
high speed
methods and
machines

Metal soundness and uniformity — For more than 20 years, unique Scovill *continuous casting* machines have been supplying a major part of the cast brass bars and billets used to produce strip, sheet, rod, wire and tube . . . over two billion pounds of metal that is inherently sounder and more uniform in every respect. This means fast running capability, minimum down-time and rejects, better quality products.

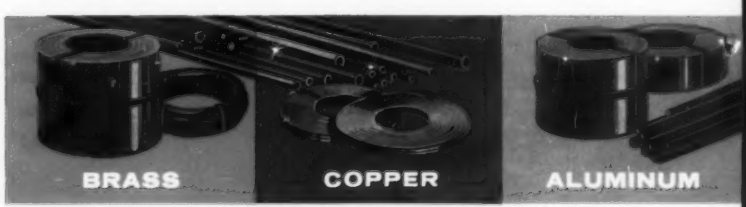
Close-tolerance specifications — Modern high-speed fabricating equipment is increasingly intolerant of what once were considered minor variations in grain size, temper, dimensions, surface finish. Scovill advanced engineering and quality-control procedures, working with new close-tolerance production equipment, meet or exceed the demands of highest-speed fabrication.

Selection of the right alloys — Scovill Metals Research maintains a continuing program of research into the practical needs of mill products fabricators. Scovill's broad range of alloys permits recommendation of exactly the right properties and qualities for a given job.

The industry's most advanced packaging — Packaging of Scovill Brass, Copper and Aluminum Mill Products can make a specific contribution to speed and efficiency in your operations . . . save you handling time and space in storage . . . cut production down-time and start-up. Scovill innovations include extra-long-run coils; Fast-Feed wire packages; easy-to-handle bundling or boxing of rod and tube.

Any fabricator who has made Scovill a part of his competitive team knows that these are only a few examples of the down-to-earth help and service he can depend upon. Call in Scovill NOW . . . especially if you want to get ideas and help in selection of the BEST metal for an important new product.

SCOVILL MANUFACTURING COMPANY
Mill Products Division, 99 Mill St., Waterbury 20, Conn., Phone Plaza 4-1171



MILL PRODUCTS

MADE IN USA

. . . and made better to bring out the ***BEST*** *in your products*

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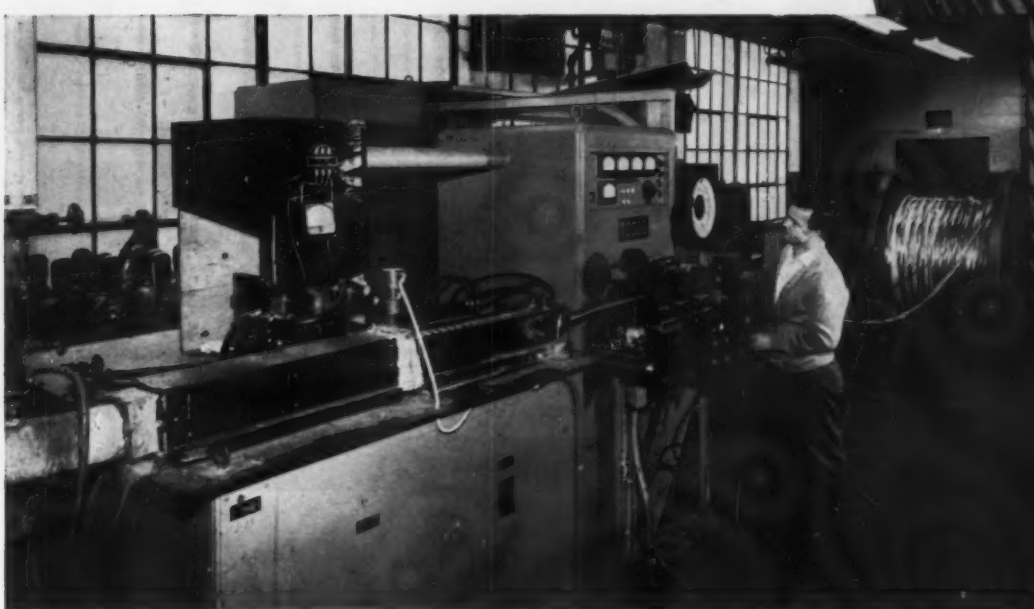
How TOCCO* Induction Annealing makes copper cable easier to handle in the field . . .



A world famous manufacturer of quality cable now treats its customers to the best with TOCCO-annealed cable that's easier to reel off, easier to splice and generally easier to handle in the field. Cable segments pass continuously through a TOCCO inductor coil at the rate of 23 feet per minute for the 800 mcm material illustrated. Many sizes of cable segments, up to one million circular mils, are annealed on one TOCCO unit.

TOCCO's many advantages over conventional annealing methods include:

1. TOCCO provides "bright annealing"—no discoloration.
2. TOCCO requires just a fraction of the space of conventional bell-type furnaces.
3. TOCCO's output is nearly four times that obtained by conventional annealing methods.
4. TOCCO equipment requires one operator as opposed to three required for the bell-type furnace operation.

Whether your products involve ferrous or nonferrous materials, look to TOCCO for an economical solution to your metal heating problems—annealing, brazing, hardening, melting or heating for forming or forging operations.

THE OHIO CRANKSHAFT COMPANY

Mail Coupon Today—NEW FREE Bulletin

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Please send copy of "Typical Results of TOCCO Induction Hardening, Heat Treating and Annealing."

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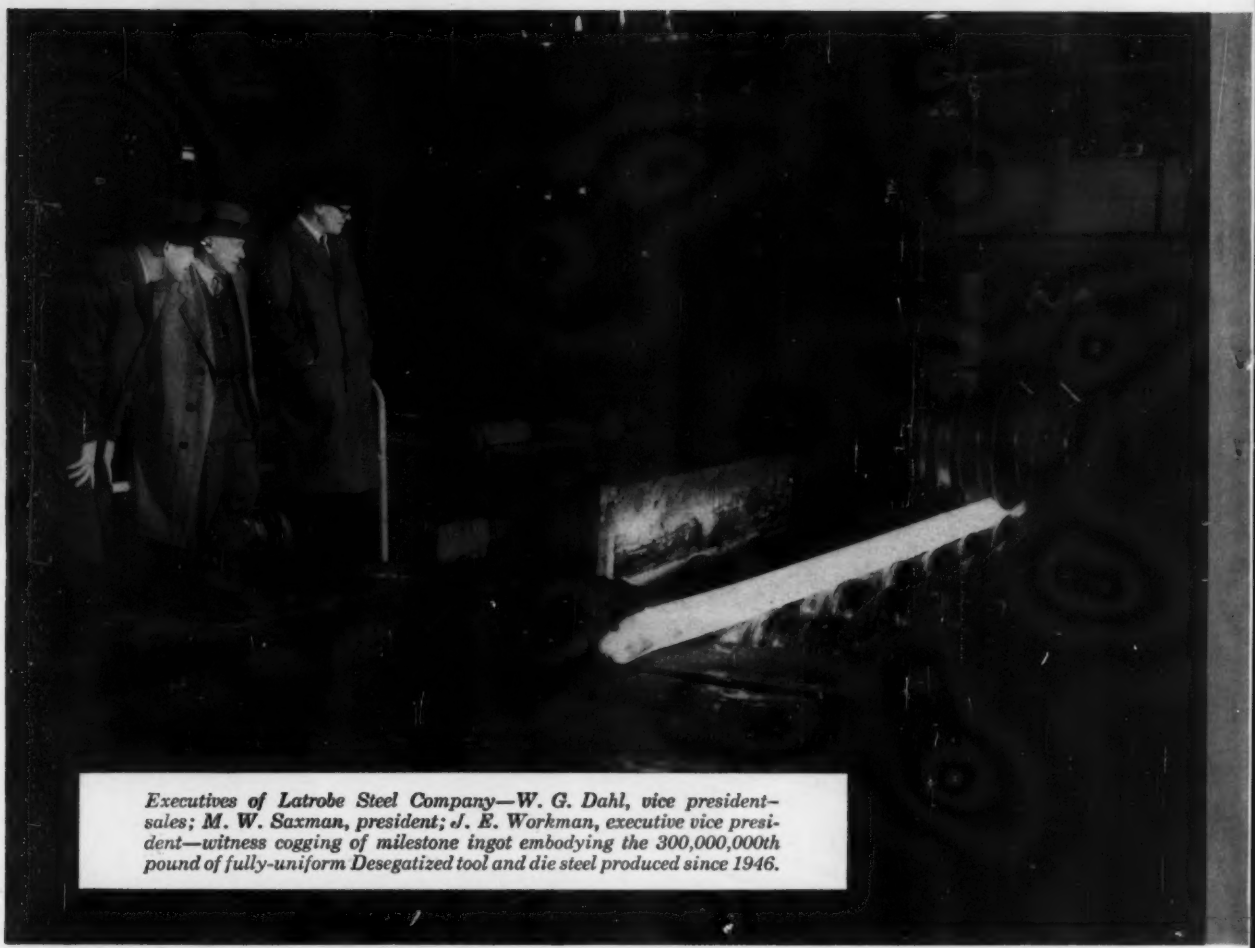
Circle 469 on Page 48-A



Executives of Latrobe Steel Company—W. G. Dahl, vice president–sales; M. W. Saxman, president; J. E. Workman, executive vice president—witness cogging of milestone ingot embodying the 300,000,000th pound of fully-uniform Desegatized tool and die steel produced since 1946.

300,000,000 lbs.

of fully-uniform

DESEGATIZED®

TOOL and DIE STEELS

for Industrial America

Made in U.S.A. by skilled Metalmasters

14 years of pace-setting quality

...it has to be good!

When first introduced in 1946, Latrobe's Desegatized process of manufacture involved new and revolutionary melting techniques. This process established new standards of quality in high speed steels and high alloy die steels. Here were steels fully uniform for the first time . . . no harmful carbide segregation . . . steels free from porosity . . . no weakening centerline inclusions!

Today, over 30 grades of Latrobe's tool and die steels are produced by the Desegatized process. These are available in regular analyses or XL and FM analyses containing properly distributed alloy sulphides for increased machinability. For manufacturers and users of cutting tools and metalworking dies, the full uniformity of Latrobe's Desegatized steels continues to mean extra toughness, greater wear resistance and reliable response to heat treatment.

Latrobe's research and development program continues. Not only will the metalworking industry benefit from better Latrobe tool and die steels, but the rigorous quality standards established through experience have been applied to the field of high strength and high temperature steels and alloys now produced for Space Age applications by Latrobe—Metalmasters for Industrial America.

Have a cutting tool, production die or specialty steel application problem? Call upon *experience* . . . Call Latrobe!

LATROBE Metalmasters

LATROBE STEEL COMPANY

LATROBE, PENNSYLVANIA

BRANCH OFFICES AND WAREHOUSES:

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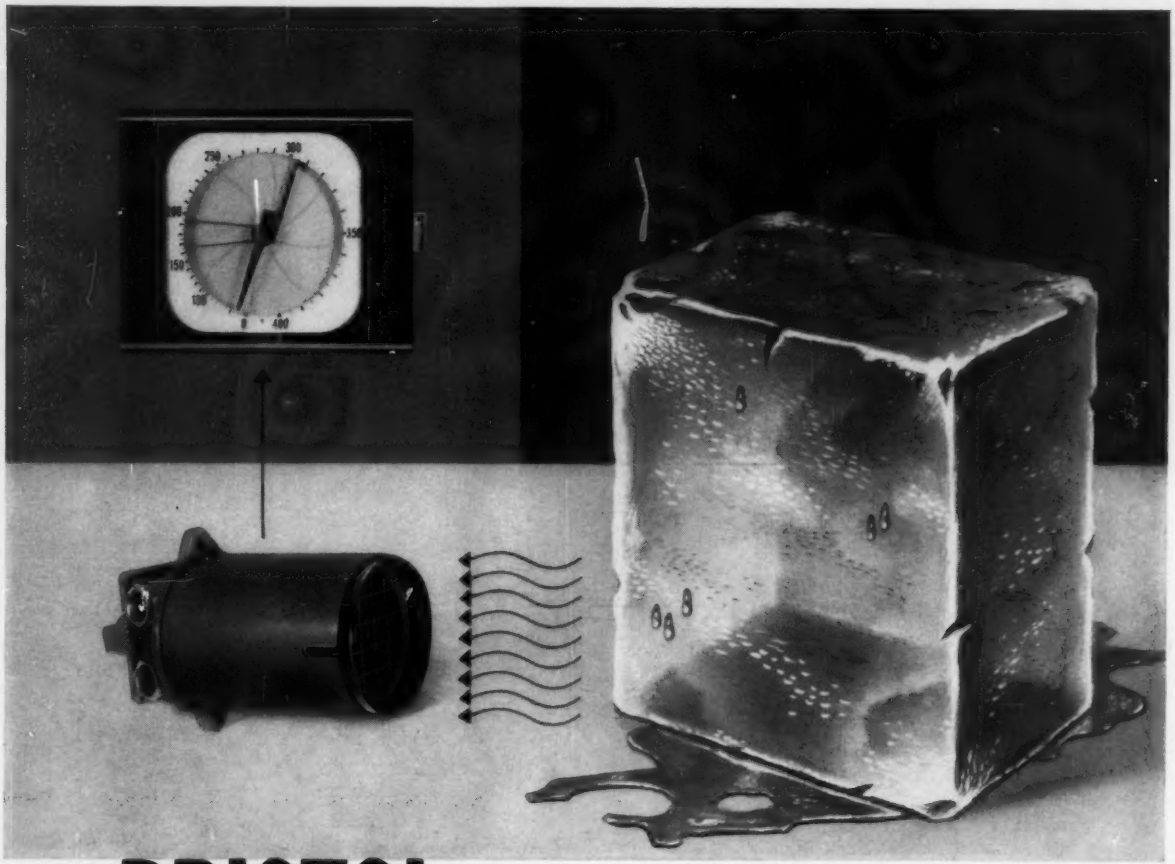


new BRISTOL low-range radiation pyrometer

IDEAL FOR NO-CONTACT, CONTINUOUS TEMPERATURE MEASUREMENTS ON

Rubber	Plastics
Synthetic rubber	Carpeting
Tile	Mineral aggregates
Roofing shingles	Chemical flows
Adhesives	Petroleum flows
Blackened or unpolished aluminum	Beverage flows
	Reactor kettles
	Mill rolls
Textiles, synthetic and natural fibres	Furnace or oven charges or exteriors
Paper	Foundry molds

...and many other substances; web processes or products; conveyed, rolled or extruded products; and stationary objects.

0-200° F and other ranges to 1100° F · Direct reading charts, scales in F or C · Calibrated interchangeable head units · Automatic built-in ambient compensation · Easy emissivity compensation

Here's the first radiation pyrometer that really gets down to 0° F.

It's the Bristol Velotron Pyrometer System—so sensitive you can sight the radiation unit (at lower left above) on your hand and get an accurate temperature indication.

And on the high end, spans and ranges are available up to 1100° F or corresponding ranges in degrees Centigrade.

Charts and scales are direct reading, in degrees F or C, even on the lowest ranges. No laborious calibration runs, calculations; no curve consulting needed! And you get famous Bristol Dynamaster* Recorder accuracy —proven in thousands of installations.

Ambient temperature compensation is automatic, completely contained in recorder unit (no third unit needed), and allows use in ambients up to 135° F.

A simple knob adjustment allows compensation for emissivity characteristics of target material from black body on down.

Interconnection cables are standard copper wire; no special, preselected lengths required.

Write for complete technical data on this outstanding new Bristol contribution to industrial pyrometry. The Bristol Company, 106 Bristol Road, Waterbury, Conn. B 31

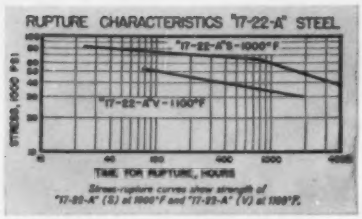
*T. M. Reg. U. S. Pat. Off.

BRISTOL...for improved production through measurement and control

AUTOMATIC CONTROLLING, RECORDING AND TELEMETERING INSTRUMENTS

Circle 470 on Page 48-A

High alloy performance with Timken® low alloy steel



You keep maximum strength up to 1100°F. If you are using expensive, high alloy steels for missile engine parts, aircraft brakes, gas turbines or other high temperature applications, try Timken® *low* alloy "17-22-A" steels. On less than 3% alloy content, you get high alloy performance—with maximum strength up to 1100°F.

Besides cutting your initial costs, Timken "17-22-A" steels have high resistance to heat checking and thermal cracking. They are readily workable up to 2300°F. and are easily machined and welded. In fact, maximum high temperature properties can be developed by normalizing and tempering. You practically eliminate the chance of distortion and quench cracking.

Want more details on this money-saving steel? Send for Technical Bulletin 36B. And let our metallurgists help solve your high temperature steel problems. They've solved thousands already. ***When you buy Timken steel you get:*** 1) *Quality that's uniform from heat to heat, bar to bar, order to order.* 2) *Personal attention from the experts in specialty steels.* 3) *Over 40 years' experience in solving tough steel problems.* The Timken Roller Bearing Company, Steel and Tube Division, Canton 6, Ohio. Cable address: "TIMROSCO". *Makers of Tapered Roller Bearings, Fine Alloy Steels and Removable Rock Bits.*

Timken Alloy Steel and Seamless Steel Tubing are available from warehouse stocks in 44 cities in the United States.

Circle 471 on Page 48-A

RIEHLE-LOS FATIGUE TESTING MACHINES

First to combine static and dynamic testing capabilities

Featuring a basic system of compatible components, new RIEHLE-LOS Hydraulically-Actuated Fatigue Testing Machines permit far greater variety and versatility in testing programs than is possible with any other machine. Available in models with capacities ranging from 12,000 to 300,000 pounds, new RIEHLE-LOS machines can be used to perform dynamic tests as well as conventional static tests.

Using the basic system of console, pulsator and loading unit, both alternating and fluctuating loadings on test specimens can be applied. Infinitely variable frequencies between 125 and 1000 c.p.m. can be obtained while the machine is being operated by the pulsator. A slow-cycle control accessory can be connected to provide frequencies from about 5 to 100 c.p.m.

By including RIEHLE recording and strain measuring instrumentation in the system, conventional static testing can be performed on the new machines. Tension and compression tests are done in the same space, so transition from one to the other is easily accomplished.

Other accessories which can be integrated to extend the utility of the machines include a programmer to automatically vary load levels and frequency and General Purpose Testing Cylinders for testing large parts and assemblies.

Installation is simplified because new RIEHLE-LOS Fatigue Testing Machines are floor models, requiring no pit.

OTHER RIEHLE TESTING MACHINES: Hydraulic and Screw Power Universal Testing Machines, Construction Materials, Impact, Brinell, Torsion, Horizontal Chain, Rope and Cable Testing Machines, Portable Hardness Testers for Rockwell Readings, etc.

MAIL COUPON TODAY FOR ADDITIONAL INFORMATION

Riehle® TESTING MACHINES

A DIVISION OF

American Machine and Metals, Inc.

EAST MOLINE, ILLINOIS

"One test is worth a thousand expert opinions"™

RIEHLE TESTING MACHINES
Division of American Machine and Metals, Inc.
Dept. MP-260, East Moline, Illinois

Please send me Bulletin RF-10-59 on the new RIEHLE-LOS Fatigue Testing Machines.

NAME

COMPANY

ADDRESS

CITY ZONE STATE

Circle 472 on Page 48-A

NEW PRODUCTS

Ferrous Metals

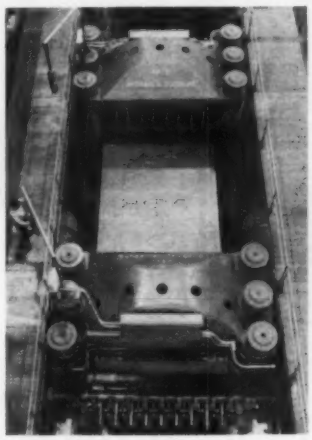
High-Strength Steel

A new high-strength steel is being marketed by *Latrobe Steel Co.* called "Viscount 44 Machinable Steel". It is high in sulphur (for machinability) and of the following composition: 0.40% carbon, 1% silicon, 5% chromium, 1.2% molybdenum, 1% vanadium. It is heat treated at the steel mill to 180,000 to 220,000 psi., tensile strength, 160,000 to 200,000 psi. yield, 10 to 15% elongation in 2 in., 15 to 20 ft.-lb. Charpy impact, and Rockwell hardness C-42 to 46.

For further information circle No. 277 on literature request card, p. 48A and B.

Nonferrous Metals

Pre-Stretched Plate



Heat treated aluminum alloy sheet, plate and wide bars have annoying out-of-flatness. This frequently-complex waviness can be corrected by cold stretching an appropriate amount. *Kaiser Aluminum & Chemical Corp.* has just placed in operation at its Ravenswood works what is believed to be the largest and most powerful stretcher in existence, capable of taking pieces of 640 sq. in. cross sectional area, or plates 6 in. thick, 13 ft. wide and 60 ft. long. Depending on the percentage elongation, the grain size of the metal is refined and the unit strength increased by the cold work. As shown in the illustration, the two heads with unusual gripping mechanism are mounted on trucks merely running on a broad gage track. Accurate alignment comes through accurate interlocked action of the stretching cylinders. Special attention was given to protecting the massive equipment from damage by energy suddenly released if the plate being stretched should break when the machine is exerting its maximum pull of 30,000,000 lb.

For further information circle No. 278 on literature request card, p. 48A and B.

Columbium Alloy

An alloy based on columbium and containing 7.5% titanium and 0.75% zirconium is the first of an anticipated series of alloys under development by *Union Carbide Metals Co.*, designed to strengthen commercial columbium and increase its oxidation resistance without additional elements which would militate against its use in atomic reactors. Rods swaged 88% and then recrystallized (1 hr. at 2600° F.) have 60,800 psi. yield strength and 32% elongation in 1 in. at room temperature and 100-hr. rupture strength of 11,500 psi. at 1800° F.

For further information circle No. 279 on literature request card, p. 48A and B.

Non-Metals

Silicon Carbide Resistors

"Crusilite" is a new tubular design of electric heating element made by *Morganite, Inc.* In one style, intended to go across the furnace from binding to binding, the end portions which would be embedded in the refractory walls are tubular and hence offer least resistance to the electric current and operate at lowest temperature, but the mid-length region inside the furnace chamber is channeled by a spiral cut to give a long spiral circuit of lesser area, and greater resistance wherein the most of the heat is generated. Another variety of the same style has a larger diameter so the resistor itself forms the wall of a small tube furnace. Still another style has both terminals at one end; the portion going through the walls is split longitudinally into two conductors, and lead into a double helix where the heat is generated.

For further information circle No. 280 on literature request card, p. 48A and B.

Electronic Materials and Equipment

Metal Replaces Glass

All-Metal "Inductosyns" have been introduced by *Farrand Controls, Inc.* These are mating zig-zag conductors aranged either in line or in circle; their purpose is to measure or control motion to 40 micro-in. (or one second of arc as the case may be). The conductor is of copper, 0.002 in. thick. Formerly the conductor was cemented to a glass plate of appropriate size or shape; now this backing is of rugged stainless steel or any desired light metal. Thus there is no uncertainty arising from different thermal expansions of Inductosyn and the machine on which it is mounted.

For further information circle No. 281 on literature request card, p. 48A and B.

Electronic Thickness Gage

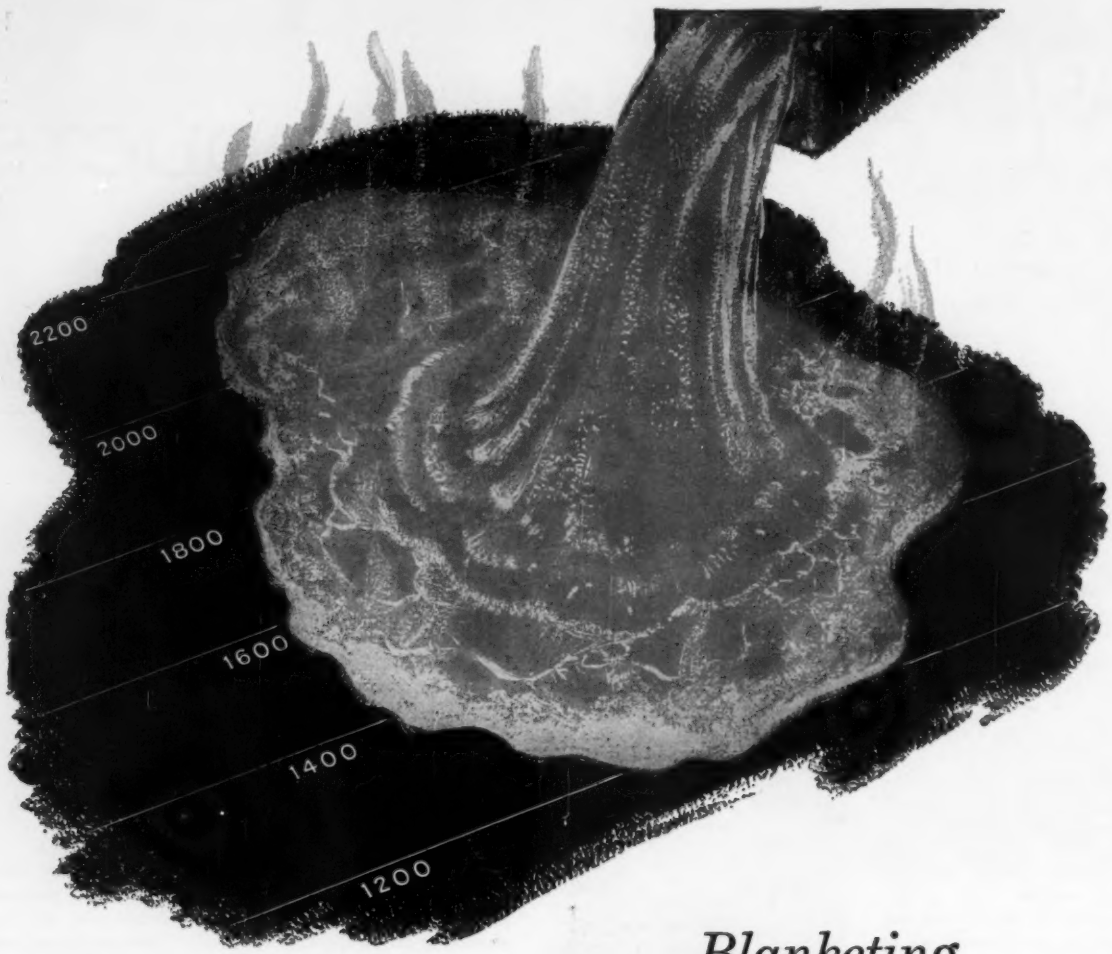
Accurate and fast measurement of thickness of metallic and nonmetallic coatings can be made with the new "Elcotector", marketed by *Ferro Corp.* The terminals set up eddy currents which vary with the conductivity of the combination of materials under test, and these currents then affect the electrical output of the sensing coil.

For further information circle No. 282 on literature request card, p. 48A and B.

Tool Materials

Gage Blocks

The DoAll Co. has perfected a stainless alloy and surface hardening treatment for the manufacture of gage blocks. Surfaces are finished to less than 0.1 micro-in., smooth enough to reflect the eye of the inspector (see engraving). A year-long shop test in competition with conventional blocks made of 52100 steel shows no corrosion, no measurable change in dimension, stable temperature coefficient



Blanketing the high temperature field

Close control is exercised over every step in the production of HAYNES alloys. This electric arc furnace is part of the modern mill set-up maintained at HAYNES STELLITE.

A fairly ambitious claim! Yet we can prove that HAYNES alloys do exactly that . . . all the way up to 2000+ deg. F. Here's why. There are 12 HAYNES high-temperature alloys. Among them you will find the right combination of properties to handle any heat condition. For example, HASTELLOY alloy X has remarkable resistance to oxidation up to 2200 deg. F. HAYNES alloy No. 25 is strong and resists stresses, oxidation, and carburization up to 2000 deg. F. HASTELLOY alloy R-235 is outstanding in the 1500 to 1750 deg. F. range. And this is only part of the story. All 12 HAYNES alloys are *production* alloys and are readily available. Some of them are vacuum melted; some air melted. Some are cast, some wrought, and some are produced in both forms. For the full story, write for literature.

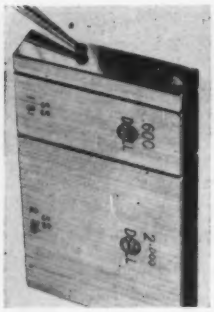
HAYNES ALLOYS

HAYNES STELLITE COMPANY
Division of Union Carbide Corporation
Kokomo, Indiana

UNION CARBIDE

The terms "Haynes," "Hastelloy," and "Union Carbide" are registered trade-marks of Union Carbide Corporation.

Circle 473 on Page 48-A



of expansion, one-millionth wear after 600 "wrings" as compared with 200 "wrings" for 52100 steel, no "brinelling" under loads, and one-quarter the nicks and burrs from ordinary use. Their rugged nature warrants their use in the shops, so machine stops can be set directly and quickly by gage blocks, and they can safely be used by shop inspectors to hold tolerances down to present-day specifications.

For further information circle No. 283 on literature request card, p. 48A and B.

Hardened Shapes

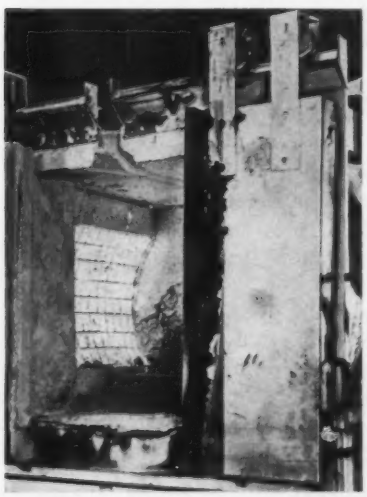
The Ohio Knife Co. has announced new additions to its line of ready-made standard hardened shapes. Now available in over 12 standard cross sections in over 80 sizes, these new sections may be used for dies, die sections, flange sections, ways, gibs, rails, wear plates, and associated uses. Section lengths run to 120 in. The hardening process produces Rockwell C-65 to 66 readings to the full depth of the toolsteel along the entire length of the section.

For further information circle No. 284 on literature request card, p. 48A and B.

Industrial Heating

Luminous Wall Furnace

Ten minutes from light-up to 2000° F. is claimed for the luminous-wall heat treating furnace. Exterior of the furnace is a barrel-shaped steel binding. Lining is a porous refractory passing a properly proportioned air-gas mixture; thus the brick acts as a heat regenerator, the cool gas entering from the back side cools the body of the refractory while the gas flowing through becomes progressively



hotter. The hot gas emerging burns in a short flame and heats the walls rapidly, and heat radiates into the furnace load. The interior can be quickly cooled by substituting compressed air for the air-gas mixture. *A. F. Holden Co.*

For further information circle No. 285 on literature request card, p. 48A and B.

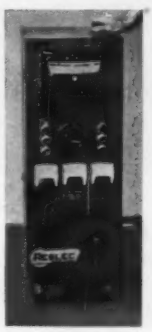
Chilling Unit for Production

Cincinnati Sub Zero Products offers a compact and complete unit for chilling (stabilization) of metal products or for environmental testing. The cold chamber holds two wire work baskets, 33 by 22 by 9 in. in dimensions, immersed in a refrigerated liquid at −150° F. which is adequately circulated by an agitator draft-tube assembly. 500 lb. of steel per hr. can be chilled from 70° F. to −110° F. in this device.

For further information circle No. 286 on literature request card, p. 48A and B.

Wire Heater

A portable "Reslec" resistance heating unit no larger than a three-drawer letter file is now available. The only connection needed is to the electrical circuit. Its 5-kw. of power can heat wire from 0.05 to 0.20 in. diameter to a temperature depending on the power input, diameter, and speed of wire travel. Normally the wire is warmed only a few hundred degrees prior to drawing or heading; such mild preheat has been responsible for a ten-fold increase in die life when heading plain carbon steels. Some important engineering alloys are so hard and strong that bolts and screws cannot be cold headed unless the stock is appropriately heated. *Herscott Corp.*



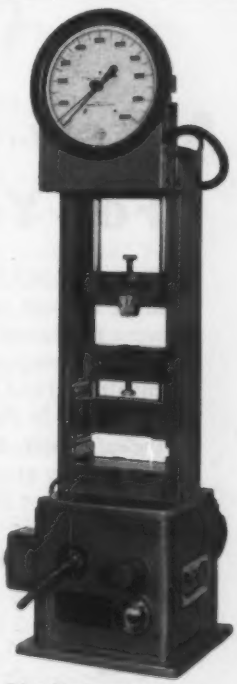
For further information circle No. 287 on literature request card, p. 48A and B.

Tensile Testers

• Motorized • Bench-Mounted
• Easy-to-Operate • Low Cost
Capacities from 1,000 to 20,000 lbs.

Available in two general sizes that occupy minimum space and provide consistently accurate and dependable results. Simple, easy-to-use controls are conveniently located on front of base. Jaws are quickly changed to accommodate specimens of different sizes. Operation is hydraulic; powered by 1/6-hp. 110-v motor. Load gage is protected from specimen-fracture shock by rubber mount. Twin load gages and floor stand are available as optional equipment.

Write or call if you have any special testing problem

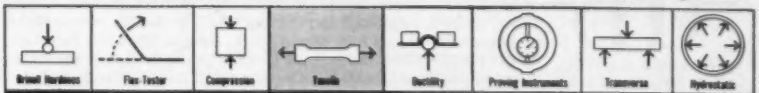


These machines are designed to also perform compression tests.

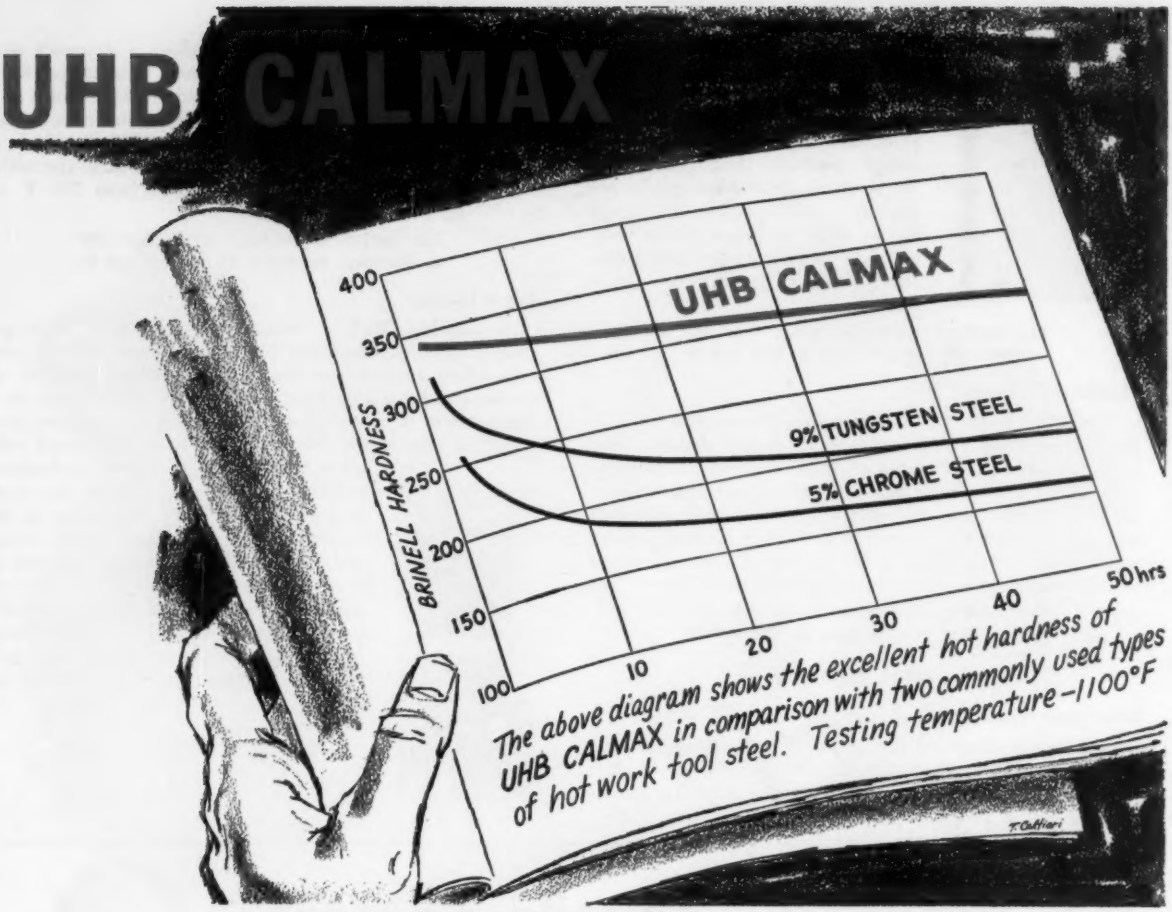
Steel City Testing Machines Inc

8811 Lyndon Ave., Detroit 38, Mich.

Distributors in most major metalworking areas



Circle 602 on Page 48-A



A New HOT WORK Steel
For Your Most Severe Applications!

UHB CALMAX is the latest Uddeholm development to meet your highest demands for hardness, wear resistance, mechanical strain and impact at elevated temperatures. It is a chromium-tungsten-cobalt steel and, when cooled in air, hardens through in all sizes. In years of testing by a major non-ferrous manufacturer, **UHB CALMAX** demonstrated extraordinary stand-up-ability to heat checking and wear. For hot press-forging, die casting, and extrusion of copper, copper alloys, and other materials with high melting points, **UHB CALMAX** outperformed 9% tungsten and similar grades of hot work steels by more than 3 to 1. In one instance, **UHB CALMAX** cores for die casting brass produced 15,500 parts, as opposed to 5000 with a 9% tungsten steel. The air hardening properties make heat treatment safe and easy. Distortion after heat treatment is insignificant!

If you need a steel that is simple to harden and that has a high hot-hardness, excellent resistance to wear and heat checking, contact your nearest Uddeholm office, today!

Ask for the UHB CALMAX pamphlet!

UHB
TOOL AND DIE STEELS
COLD ROLLED SPRING STEELS

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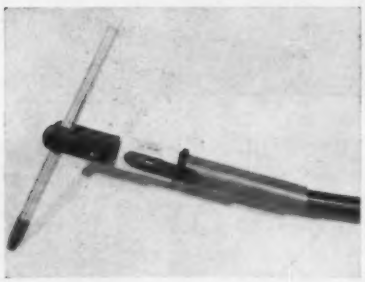
Circle 474 on Page 48-A

Cleaning and Finishing

Cleaning Torch

A unit especially designed for fast removal of metal from large surface areas is shown in the half tone. It is especially adapted for conditioning castings. It takes a large electrode, ⅝ to ¾ in., and a blast of compressed



air blows away the metal as fast as the electric current melts it. It has many safety features such as a rubber tube or boot over the end of the cable carrying both electric current and air stream. *The Arcair Co.*

For further information circle No. 288 on literature request card, p. 48A and B.

Ultrasonic Degreaser

The completely self-contained Model AC-25 "Sonogen", built by *Branson Ultrasonic Corp.*, shown in the cut, removes soil from intricate parts and even from completed assemblies. The cleaning tank has transducers to convert electric energy into mechanical vibrations, an ultrasonic generator of 40,000 cycles per sec., a

boiling sump, and a recirculating and filtering system for the solvent. After degreasing, the work is spray rinsed, placed in the vapor zone, and dried. A variety of safety devices limit evaporation losses, protect the heating system from overheating, guard against leakage, and protect the operator from high voltage.

For further information circle No. 289 on literature request card, p. 48A and B.

THE MARK OF QUALITY

BARBER COLMAN

Wheelco Instruments

Accuracy of 4500° F Curtiss-Wright lab furnace assured by Wheelco controls

The furnace. A product of Curtiss-Wright Corporation, Santa Barbara, California, the helium atmosphere furnace illustrated is designed for continuous operation at 4500° F, intermittent operation to 5100° F. An extremely compact graphite resistance heating element permits a working chamber of 8" high by 4" diameter inside a unit only 20" high by 10⅛" diameter. Cooling is provided by flow of water through portions of the outer shell.

Wheelco controls. For exacting control, Curtiss-Wright recommends a Wheelco Model 8100 potentiometer-recorder with 100 ohm slide wire, MMC current output type magnetic modulated controller, step-down transformer, saturable reactor, and a Wheelco-Land radiation pyrometer with sensing element and vernier adjustment. The MMC controller has an adjustable proportional band and automatic reset and rate action. The standardization is continuous.

Complete information and literature on request.

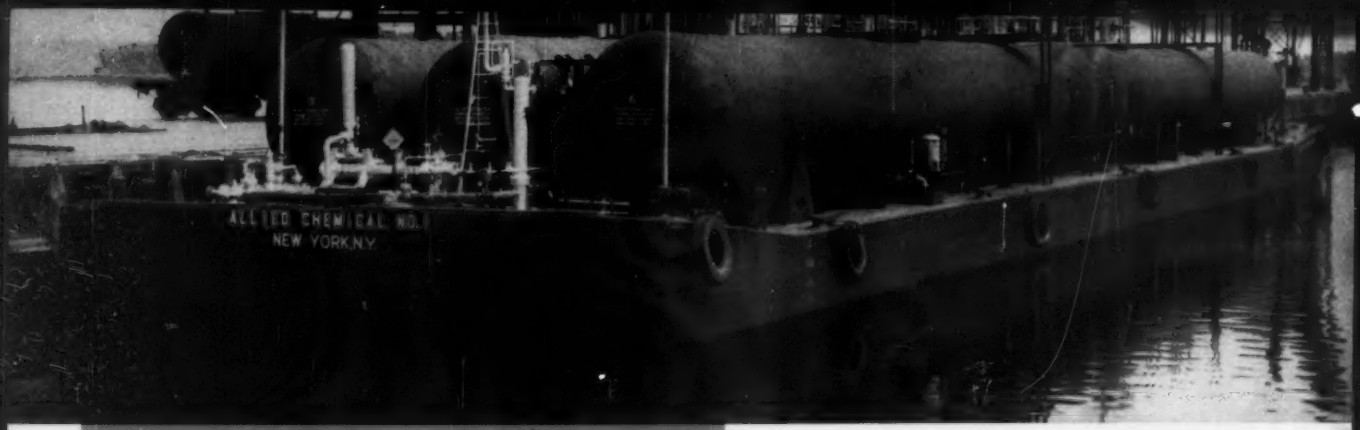
BARBER-COLMAN COMPANY

Dept. B, 1518 Rock Street, Rockford, Illinois, U.S.A.

BARBER-COLMAN of CANADA, Ltd., Dept. W, Toronto

Export Agent: Ad. Auriema, Inc., New York

Circle 607 on Page 48-A



QUESTION— TO USERS OF AMMONIA FOR METAL TREATING...WHAT SIZE CONTAINER PLEASE?

For pure, dry, oil-free anhydrous ammonia for your dissociators — in the container that best fits your needs — specify Allied Chemical. You name it—tank cars . . . transport trucks . . . tank wagons . . . cylinders . . . and even barges — Allied Chemical can supply it.

Plants and bulk storage terminals are located at strategic points for fast delivery. Write or call for specifications, shipping information or technical assistance. Remember, you can equalize freight, but you can't equalize experience. Nobody has more ammonia experience than Allied Chemical.

For specifications and local offices, see our insert in Chemical Materials Catalog, pages 475-482 and in Chemical Week Buyers Guide, pages 37-44.

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NITROGEN DIVISION

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Circle 566 on Page 48-A

2819

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A MAJOR BREAK-THROUGH IN MODERN RESEARCH TOOLS

FEATURING A MACHINE THAT FINDS INFORMATION

Write for complete details:

ASM
DOCUMENTATION SERVICE
Metals Park,
Dept. P2
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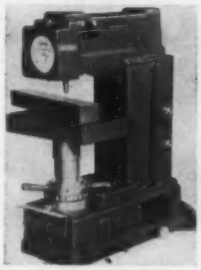
Inspection and Control

Motorized Hardness Tester



Now available from *Torsion Balance Co.* is a newly designed hardness tester utilizing the indentation principle. To eliminate much of the personal element and operator fatigue, it automatically removes the major load after the test is completed. It can be used for either regular Rockwell tests or the superficial Rockwell test, and a design is available in which both tests can be performed in a single machine.

For further information circle No. 290 on literature request card, p. 48A and B.

Vacuum Gage

A rugged and simple vacuum gage is now marketed by *NRC Equipment Corp.* which measures gas pressure by the amount of heat the residual gas conducts away from a hot wire. The sensing element is a combination heater and thermocouple. Cross-shaped, it is formed by spot-welding the mid-points of two short resistance wires of different compositions. With a known current from batteries flowing through one wire, the temperature at the junction, which depends on the conductivity of the gas (and therefore on its pressure), is indicated by the electromotive force sent out through the other pair and conducted to a direct reading millivoltmeter calibrated to microns pressure. The scale reads from 2 mm. Hg down to 1 micron. The equipment box weighs 3 lb. and its face shows only the millivoltmeter and three control switches. It slips readily into a brief case.

For further information circle No. 291 on literature request card, p. 48A and B.

Equipment

Billet Marker

Putting identification marks on billets, slabs or blooms in the rolling mill has always been a difficult, costly and fatiguing job. An almost completely automatic machine for this chore has now been designed by *Jas. H. Matthews & Co.* The stamping head aligns itself to the surface of the cut billet end and immediately a powerful impact drives the character wheels into the metal to be marked. Thereupon the head retracts and a set of indexing wheels lowers and engages the stamping wheels. An operator at a remote console indicates what changes are to be made; by electrical circuits the proper stamping wheel or wheels are moved to new position; the characters appear on the console for the operator to verify; the indexing mechanism disengages itself and the machine is ready for the next operation.

For further information circle No. 292 on literature request card, p. 48A and B.

Parts and Shapes

Aluminum Tube Turns

A considerable amount of tubing with walls 35% thinner than standard are used throughout American industry today where pressure and other conditions can be safely met. Fittings for such pipe are available in nickel alloys, and *Tube Turns* is now making "Pipe-Mate" fittings of Type 6063-T 6 high-strength aluminum alloy. These are readily joined by butt or fillet welding, brazing with an aligned connector, and by "rolled-in" flange assembly wherein the pipe or fitting is expanded into an aluminum insert and the flange rotates easily about the insert for easy alignment of bolts.

For further information circle No. 293 on literature request card, p. 48A and B.

metal abrasives
TAILOR MADE
for you...

We can now make, and deliver in every shipment, the exact type of "Malleabrasive" shot or grit that will do your particular job best . . . and at lowest cost to you.

With new, precision controlled equipment and specialized techniques "Malleabrasive" is now job-made to meet each individual cleaning condition.

Why settle for make-shift, general purpose abrasives when you can have "Malleabrasive" tailor-made for you? We'll welcome the chance to tell you how you can benefit.

Write us.

THE GLOBE STEEL ABRASIVE CO.
Mansfield, Ohio

Sold by many leading distributors of foundry supplies from coast to coast.

Circle 661 on Page 49-A

MALLEABRASIVE

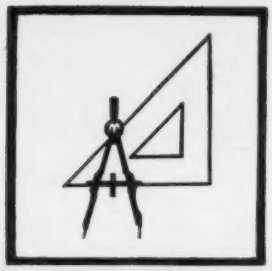
Take me to your buyer ...I'm the leader!

• Want to bring your brush costs down to Earth? Pittsburgh's complete line of power-driven and hand brushes... for any job, in any industry... can lead the way.

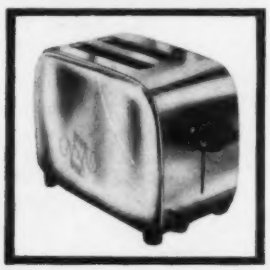
• For the address of your Pittsburgh Brush supplier, write or CALL COLLECT, Pittsburgh Plate Glass Co., Brush Div., 3221 Frederick Ave., Baltimore 29, Md.

PITTSBURGH PLATE GLASS COMPANY

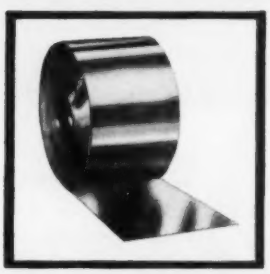
Circle 475 on Page 48-A



FROM DRAWING BOARD



TO FINISHED PRODUCT...



FASTER WITH NICKELOID

Finished Raw Material Fabricated with Standard Production Methods

In tune with the times, are Nickeloid Metals. They provide design freedom and manufacturing simplicity with three of five production steps eliminated. The Nickeloid Method gets a new model or product rolling in production, fast! Quicker to shipping dock . . . saves on tooling and equipment outlay . . . lower inventory of parts in process. They simplify, simplify, simplify: in design, in purchasing, in production. Made as only 61 years of special know-how can refine a product with deep-down durability and quality. Practical: can be formed, stamped, bent, crimped, seamed, blanked, soldered, etched, spot-welded. Gleaming finishes of chromium, nickel, copper, or brass electroplated steel and other base metals. Sheets, strips, coils — polished or satin. A galaxy of breath-taking stripes, patterns, crimps and textures. Protective Mar-Not coatings. See Sweet's Catalog for additional information, or write us for Introductory Kit, which includes metal samples.

NICKELOID METALS SINCE 1890

American Nickeloid Company
Peru 2, Illinois
Plants: Peru, Ill., and Walnutport, Pa.

Circle 476 on Page 48-A

AN IMPORTANT MESSAGE FOR ELECTRIC STEEL FURNACE OPERATORS

The performance requirements of graphite in nuclear and space age applications are spurring advances in graphite technology that were unheard of a few short years ago.

Research and development progress attributable to these newer graphite uses is rapidly adding to the fund of technical knowledge of graphite's unique properties, and to increasingly tighter controls in its manufacture.

GLC graphite is now employed in many of today's new applications such as nuclear moderators, missiles, rockets, honeycomb steel brazing and so on.

Users of GLC electrodes in electric steel furnaces can be sure that GLC graphite specialists are making significant contributions in these advanced technological areas—and that their findings are being translated into improvements in GLC electrode columns and superior customer service.

We welcome opportunities to assist you in lowering electrode costs per melt ton.

PRODUCTS ELECTRODE GLC DIVISION YOU CAN TRUST

GREAT LAKES CARBON CORPORATION

18 EAST 48TH STREET, NEW YORK 17, N. Y. OFFICES IN PRINCIPAL CITIES

Circle 599 on Page 48-A

Metal components being conveyed into a sintering furnace at the Norwalk Powdered Metal Products plant. These components ride on a Wissco Belt through temperatures up to 2050° F.

FAMOUS NAMES
ride on WISSCO BELTS
Norwalk Powdered Metal Products, Inc.

This is the image of CF&I. He symbolizes the modern manufacturing techniques that assure the long-range dependability of all CF&I steel products, including Wissco Metal Belts.

The story of Wissco Belts is best told by their users: For instance, Mr. Harry Moss, Production Manager for Norwalk Powdered Metal Products, Inc., of Norwalk, Conn., reports:

"We use Wissco Belts exclusively because they last so long and because they can be replaced within minutes. In the course of its working lifetime, the average Wissco Belt we employ conveys 25 million powdered metal parts through sintering furnaces—at temperatures up to 2050° F, 24 hours a day. We are sold on Wissco Belts because they last an average of four months longer than competitive belts."

The durability of Wissco Belts was stressed by an incident which happened one weekend when the furnace was unattended. A failure of the driving mechanism occurred on the furnace, immobilizing the 60' x 12" Wissco Belt throughout Saturday and Sunday. Norwalk's production department was impressed by the fact that the section of the belt within the furnace withstood this unnatural concentration of heat so successfully during the entire period. This belt is still being employed, without any repairs required.

There's a Wissco Belt designed for every processing-conveying operation. A CF&I engineer will be glad to survey your production set-up and recommend the Wissco Belt that will make your operation more efficient and economical. For complete information, call the nearest CF&I sales office.

WISSCO BELTS

THE COLORADO FUEL AND IRON CORPORATION

CF&I STEEL

In the West: **THE COLORADO FUEL AND IRON CORPORATION**
Denver and Oakland

In the East: **WICKWIRE SPENCER STEEL DIVISION** — Atlanta · Boston Buffalo · Chicago · Detroit · New Orleans · New York · Philadelphia

Circle 477 on Page 48-A

7175

Cold rolled anneal and pickle line at Jones & Laughlin Steel Corporation's Louisville, Ohio plant

Wean, J&L and Stainless . . .

Eleven continuous processing lines at Jones & Laughlin's impressive new stainless plant—*all designed and built by Wean Engineering*—demonstrate the versatility of Wean's abilities in this field. From conditioning of incoming coil, through annealing, pickling and surface treatment, to slitting and cut-up, these Wean lines assure Jones & Laughlin customers top quality stainless strip or sheet to meet the most exacting requirements.

In the design of this equipment, high quality surface finish of the stainless was a prime requisite—one of the reasons Wean was selected to engineer and build this multi-line installation. Whatever *your* requirements in continuous strip processing, you can benefit from Wean's *creative engineering.*

THE WEAN ENGINEERING COMPANY, INC. • WARREN • OHIO

Beat the Heat Barrier With Handy & Harman High Temperature Brazing Alloys!

Some of the problems of elevated temperature joint strength and oxidation resistance in heat-resistant alloys are being solved today by a relatively new group of Handy & Harman high temperature brazing alloys. These alloys embody certain unique characteristics, all of which are requisite for high temperature brazing:

- They have good strength and oxidation resistance at recommended temperatures.
- They are ductile, with the ability to withstand vibration and stress at elevated temperatures.
- These Handy & Harman alloys provide minimum solution and penetration of the metals being joined; this is a particular advantage when joining thin sections.
- These alloys effectively join stainless steels, low alloy steels, nickel-base alloys, cobalt-base alloys and other high temperature metals including refractory types.

The list of successful applications includes jet engine parts, heat exchangers, rocket motors, clad metals, honeycomb structures, turbine blades and many others. The following are brief descriptions of these Handy & Harman alloys:

LITHOBRAZE 925 For short time operation to 900° F, continuous at 500° F. Very ductile, virtually no solution of base metal. Good salt-spray corrosion resistance.

HI-TEMP 30 For continuous service 900° F-1000° F. Fairly ductile, moderate general solution of base metal.

PREMABRAZE 128 Continuous service up to 1500° F. Ductile, moderate solution of the base metal. Tensile strength at 1600° F in 304 stainless steel is 20,000 psi (short time test).

PREMABRAZE 130 Same properties as PREMABRAZE 128, but freer flowing and lower brazing temperature.

PREMABRAZE 101 Continuous operation in 1800° F-2000° F range (based upon limited oxidation tests). Ductile, moderate solution and penetration of the base metal.

Alloy	Nominal Composition	mp° F	fp° F
LITHOBRAZE 925	92.5 Ag 7.3 Cu .2 Li	1435	1635
HI-TEMP 30	70 Mn 30 Ni	1885	1920
PREMABRAZE 128	72 Au 22 Ni 6 Cr	1785	1900
PREMABRAZE 130	82 Au 18 Ni	1740	1740
PREMABRAZE 101	54 Pd 36 Ni 10 Cr	2250	2300

Data sheets and complete details on each of the above Handy & Harman alloys are available upon request to Handy & Harman, 82 Fulton Street, New York 38, N. Y.

Your NO. 1 Source of Supply and Authority on Brazing Alloys

HANDY & HARMAN

General Offices: 82 Fulton St., New York 38, N. Y.

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OAKLAND, CALIF.
TORONTO, CANADA
MONTREAL, CANADA

Circle 567 on Page 48-A

Quality control at Standard is second to none among the nation's major specialty product steel plants. It is maintained by the most accurate, up-to-date testing equipment available. The laboratory facilities operate around the clock to keep all vital information flowing to our metallurgists, shop foremen, mill and machine operators—as well as to plant management, and, of course, our customers.

Bring your next unusual product to us—we'll welcome the opportunity to serve you regardless of the alloy it might require. Send for the free illustrated booklet, "Quality Control at Standard."

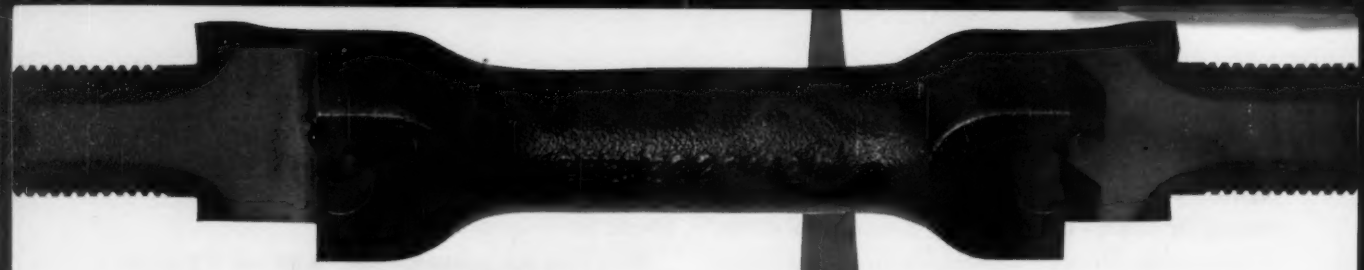
Standard Steel Works Division

BALDWIN · LIMA · HAMILTON

BURNHAM, PENNSYLVANIA

Rings • Shafts • Car wheels • Gear blanks • Flanges • Special shapes

Circle 478 on Page 48-A



CINCINNATI "oscillating" Flamatic

uniformly hardens 2 sizes of steering control arm shafts simultaneously

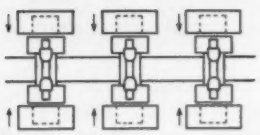
430 parts hardened per hour of one size;
125 per hour of a larger size

For high production surface hardening of two sizes of steering knuckle control arm shafts, a major automobile manufacturer has installed the Cincinnati® Flamatic® Flame Hardening Machine shown below.

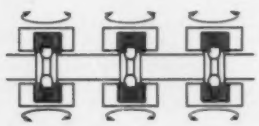
This Flamatic, fueled by city gas and oxygen, has two independent heating stations. The right-hand station selectively hardens both ends of three shafts simultaneously; the left-hand station hardens both ends of one shaft. Thus one machine processes two similar parts having widely different production quantity requirements. Operating sequence of the three-at-a-time station is described at right.

The part, of 1045 Steel, sectioned to show the hardness pattern, is illustrated above. Specified areas to be hardened include the threaded section, fillet, and square shoulder, at both ends. Minimum depth of case produced is .016″ below thread root, .030″ at fillet, with minimum hardness of 55Rc.

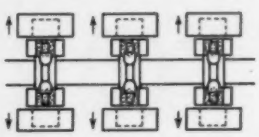
This Flamatic met the heat treating and production rate specifications of these critical parts. To solve your heat processing problems, call in a Meta-Dynamics Division field engineer. Cincinnati builds *both* flame heating and induction heating machines for high production as well as varied, short-run work.



1. Operator loads three shafts on locating pins of chain conveyor. Parts index to three opposed pairs of flame heads.



2. Flame heads ignite and advance to surround both ends of each shaft. Flame heads oscillate to provide uniform heating of all surfaces to be hardened



3. Flame is extinguished and flame heads retract. Quench heads advance and apply soluble oil spray.

4. Quench is cut-off and quench heads retract. Conveyor indexes next three parts and sequences repeat.

Circle 479 on Page 48-A

inductron
flamatic
hardening machines
META-DYNAMICS DIVISION
Machines for Metal Forming and Heat Treating
THE CINCINNATI MILLING MACHINE CO.
Cincinnati 9, Ohio, U.S.A.
CINCINNATI

NEW LITERATURE

Ferrous Metals

295. Standard Steels

Compositions of standard steels, correlating S.A.E. and A.I.S.I. numbers and A.S.T.M. and Federal specifications are listed in 20-p. manual. Includes carbon, alloy and stainless grades. *Jones & Laughlin Corp.*

296. Alloy Steels

Booklet on "Aristoloy Stainless and Carbon Steels," describes full line of product made to standard and leaded analyses of prime surface condition. *Copperweld Steel Co.*

297. Heat Resisting Steels

Annual review of progress in all phases of manufacture and use of high-temperature steels and alloys. *Timken Roller Bearing Co., Steel & Tube Division*

298. Ferrochromium

Fast-dissolving, low-carbon ferroalloy described in folder "Simplex Ferrochrome". *Union Carbide Metals Co.*

299. Superalloys

36-p. book entitled "Superalloys by Vacuum Induction Melting" describes 50 metals for such things as gas turbine blades, missile and nuclear components. *Kelsey-Hayes Co.*

300. Alloy Steels

Series of data sheets giving facts about analysis, heat treatment, fabrication and uses of A.I.S.I. standard steels and several special-analysis steels. *Bethlehem Steel Co.*

301. Stainless Steels

Technical booklet on AM 350 and 355 describes two precipitation hardening steels suitable for use up to 1000° F., readily weldable and formable. *Allegheny Ludlum Steel Corp.*

302. "Super" Alloy Steels

"Mid-Vac" steels, produced by consumable electrode melting in vacuum, with superior physical properties at elevated temperatures. *Midvale-Heppenstall Co.*

303. Spring Steel

Brochure gives data on "2R25", a superior stainless spring steel, tough, resilient, formable, it has fatigue life 10 fold that of carbon spring steel. *Sandvik Steel, Inc.*

304. High-Strength Steel

"Stressproof" steel bars (copper bearing) delivered with 100,000 psi. tensile strength, machinable into machine parts needing no heat treatment. Technical bulletin from *LaSalle Steel Co.*

Nonferrous Metals

306. Tellurium Copper

Technical data sheet gives physical and mechanical properties and hints on fabrication. *Bridgeport Brass Co.*

307. Porous Metal

Porous metal for impregnated bearings, driving bands, self-cooling turbine blades and filters. *Bendix Aviation Corp.*

308. Refractory Metals

Discussion of utility of tantalum, titanium and zirconium for equipment for electroplating and electropolishing. *The Pfaudler Co.*

309. Platinum

Platinum-clad metals in sheet, strip, foil, rod, wire and tubing. A wide variety of metals are clad in this way. *Metals & Controls*

310. Copper Alloys

24-p. manual on alloys in rod form; typical parts; specifications for alloys described. *Mueller Brass*

311. Molybdenum

Bulletin discussing the corrosion resistance of molybdenum and its commercial alloys to various acids, salts, hot gases and liquid metals. *Climax Molybdenum Co.*

312. Molybdenum

12-p. brochure lists commercial forms (powder, shapes, pellets, rod, wire) and explores numerous fields of utility. *Sylvania Electric Products, Inc.*

313. Lithium

Bulletin 101 describes industrial uses of this light metal, such as for scavenging oxygen and hydrogen from molten alloy steels and thus promoting soundness in ingots or castings. *Foote Mineral Co.*

314. High-Nickel Alloys

Booklets, pamphlets and data sheets on high-nickel stainless and heat resisting steels and alloys. *International Nickel Co.*

315. Haynes Alloys

Information on nature, fabrication, and uses of alloys for prolonged operation well above 1700° F. *Haynes Stellite Co.*

316. Silicomanganese

Information about composition of various commercial grades and their use for deoxidizing, desulphurizing and grain refining (toughening) of engineering and structural steels. *Vanadium Corp. of America*

Non-Metals

322. Refractory Castables

"Kaocast", a castable refactory suitable for temperatures up to 3000° F., and "Kaocrete-32" up to 3200° F., described in Bulletin R-35A. *The Babcock & Wilcox Co.*

323. Alumina Tubes

Technical data on porous tubes of 99+ alumina for hydrogen and cracked ammonia atmospheres up to 3450° F. *Morganite Inc.*

324. Refractory Oxides

Catalog 127 lists round tubing up to 6½-in. O.D. and straight-sided crucibles of similar diameter up to 11 in. high, of zirconia, magnesia, mullite and other materials suitable for use up to 5000° F. *Laboratory Equipment Corp.*

325. Hard Carbides

Kennametal Inc. has information on "Kentanium" series of hard titanium carbide formulations and recently developed Grades K601 and K701 for corrosion resistance.

326. Cryolite

Small book on properties of natural cryolite from Greenland and its many uses as molten solvent for refractory oxides, in ceramic formulations and in abrasives. *Pennsalt Chemicals Corp.*

Electronic Materials

328. Single Crystals

Bulletin 102 lists sizes and shapes of "off the shelf" items suitable for electronic circuits and as laboratory standards. *Flow Corp.*

329. Cathodic Vacuum Etcher

Information on cathodic vacuum etcher in models suitable for either remote handling in radioactive areas or for direct use. *Nuclear Materials & Equipment*

330. Zone Melting

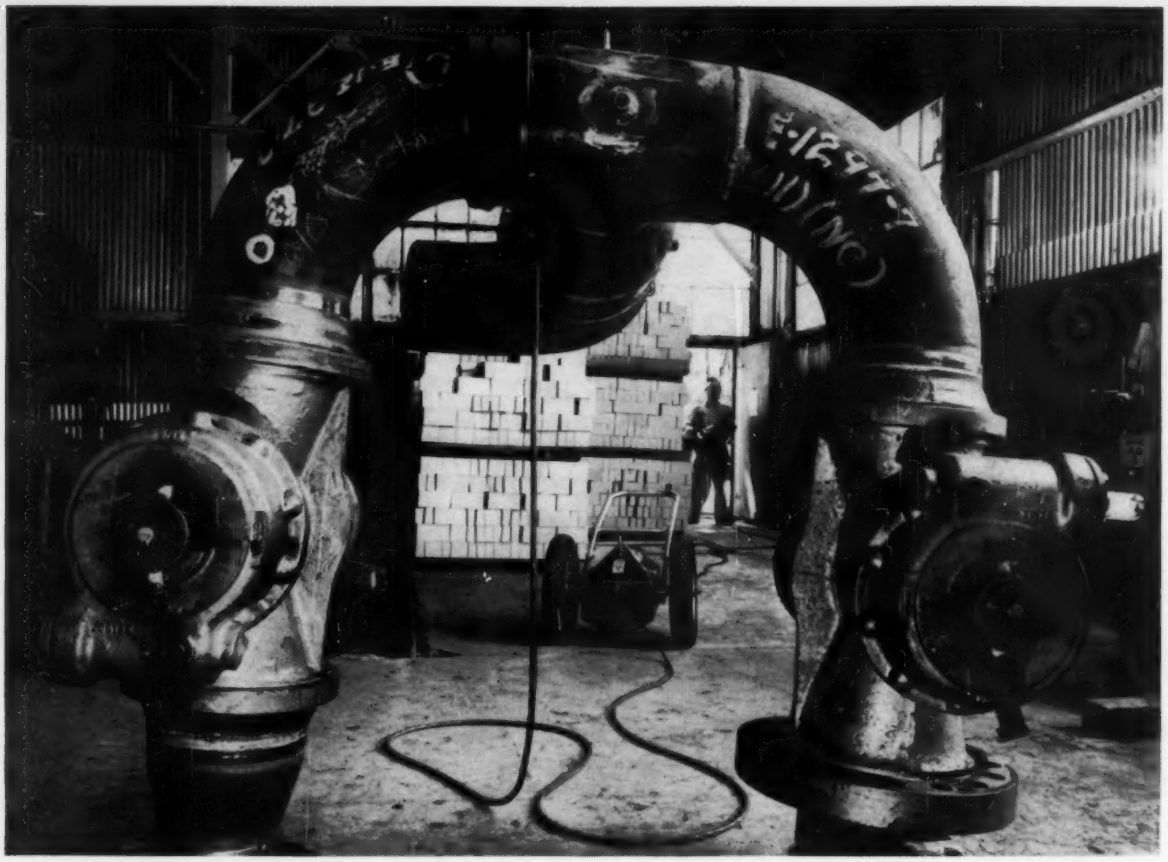
Vol. 1, No. 6 or "High Frequency Heating Review" discusses floating zone method for refining and for growing germanium or silicon crystals for transistors. *Lepel High Frequency Laboratories, Inc.*

331. Tagged Compounds

General catalog of chemicals (gaseous, liquid and solid) containing known amounts of radioactive C-14. *Research Specialties Co.*

332. Semi-Conductors

Charts showing properties of high-purity elements used in semi-conduc-



The entire circumference of the left hand weldment at the Tee fitting of this pipe assembly is being radiographed in a single exposure with a Model 50 Multitron. The unit can handle any isotope suitable for gamma radiography . . . and up to four separate sources can be contained in the same machine. A wide variety of exposures can be made—internal, panoramic and beam. Model 50 travels with ease anywhere in plant or field, requires no external power.

VERSATILE! Budd IRIDITRON and MULTITRON units for gamma radiography

- **Exclusive multiple-source heads**
- **Source strengths to 1000 curies**
- **For all exposures—beam, panoramic, internal**

Select the radiography equipment that meets your requirements from the 21 standard Iriditron and Multitron Models now available. One of these models will give you the method or methods of exposure, number of sources, source materials, source strengths, and type of mounting you need. Each model is distinguished by design features that assure you unsurpassed versatility, performance, and safety.

Get complete service from Budd—including radioactive source supply and encapsulation, source replacement and disposal, training for your personnel (without charge) and aid in setting up complete radiographic facilities.

Write or call Budd Instruments Division for our Gamma Radiography Bulletin . . . or for a consultation on your requirements.

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THE Budd COMPANY

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Merchant's Exchange Bldg. Room 316
465 California St., San Francisco, Calif.
In Canada:
Tatnall Measuring and Nuclear Systems, Ltd.
46 Hollinger Road, Toronto 16, Ont.

Circle 568 on Page 48-A

tors, "doped" alloys and phase diagrams. *Anchor Alloys, Inc.*

333. Oscillographs

Specifications and features of "Datarite" recording oscillographs for 18 or for 26 channels. *Electro Mechanical Instrument Div. of Consolidated Electrodynamics Corp.*

Tool Materials

334. Grinding Wheels

List of six shapes in 27 sizes of abrasive wheels which cover 90% of all portable grinding wheels. *Chicago Wheel & Mfg. Co.*

335. Flame Cutting Machine

Airco's "Linagraph", with electronic tracer, pantograph arms, and motorized torches, handling plate up to 8 ft. wide, described in Catalog 804 L. *Air Reduction Sales Co.*

336. Punching and Notching Units

Catalog of units which can be accurately placed in a press and punch several holes simultaneously in a sheet of metal. *Punch Products Corp.*

337. Draw Lubricant

"Draw Clean M" is described in Bulletin F-10393. Clings tightly to aluminum surfaces, yet is soluble in wash waters and volatile at annealing temperatures. *Oakite Products, Inc.*

338. Tool and Die Steel

"Vega" air-hardening steel (A.I.S.I. Type A-6), of superior uniformity, cleanliness, machinability. Data from *Carpenter Steel Co.*

339. Cutting Processes

Brochure describes in-plant courses to suit needs of your company. *Metals Engineering Institute*

Heating Equipment

342. Heat Exchanger Tubes

8-p. brochure describes tubing for power, petroleum and marine equipment of various copper alloys as well as duplex tubing. *Scovill Mfg. Co.*

343. Immersion Heaters

12-p. bulletin on "Karbate" heat exchanges made of impervious graphite, for operation in corrosive solutions. *National Carbon Co.*

344. Atmosphere Generators

Catalog Section 24 decribes endothermic gas generators, reversible in direction for self-cleaning of catalyst beds. *Rolock, Inc.*

345. Rapid Heat Processing

"Gradiation"—or heat processing so designed as to coordinate heating rate with nature of object being heated—as applied to various steel mill operations is discussed in Bulletin S 1056. *Selas Corp. of America*

346. Practical Heat Treatment

32-p. booklet describes lesson courses in fundamentals, suitable for home study or in-plant training programs. *Metals Engineering Institute*

NEW NEW NEW NEW NEW NEW NEW NEW NEW

WHEN IT

MELTS

you know the *temperature!*

the easy modern way to determine exact working temperatures!

Just mark or stroke the surface with THERMOMELT . . . when it reaches the desired temperature, the mark liquefies. There's no guesswork, no wasted time or material . . . THERMOMELT is the quick, precise way to determine heating temperatures. Accurate to within ±1%.

A STIK FOR EVERY TEMPERATURE from 113°F. to 2000°F.

ALSO AVAILABLE IN LIQUIDS AND PELLETS for inaccessible or hard-to-measure applications. Wide range of temperatures.

Send today for free THERMOMELT literature and pellet sample (indicate temperature desired).

MADE BY THE MANUFACTURERS OF MARKAL PAINTSTIK MARKERS AND PROTECTIVE COATINGS

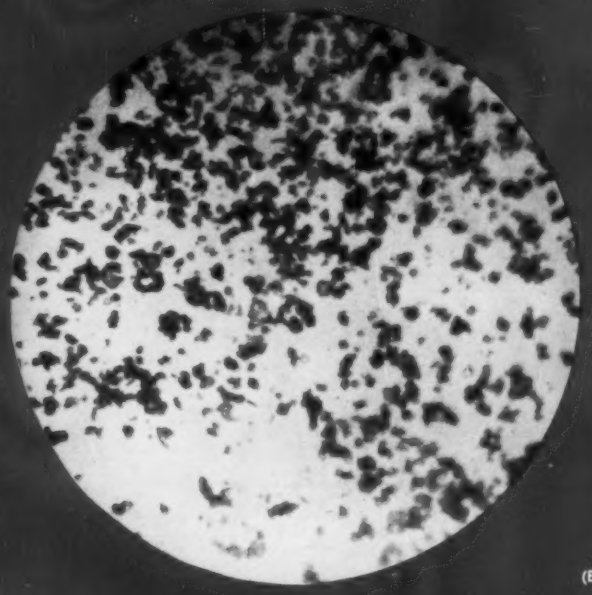
MARKAL COMPANY 3118 West Carroll Avenue, Chicago 12, Illinois

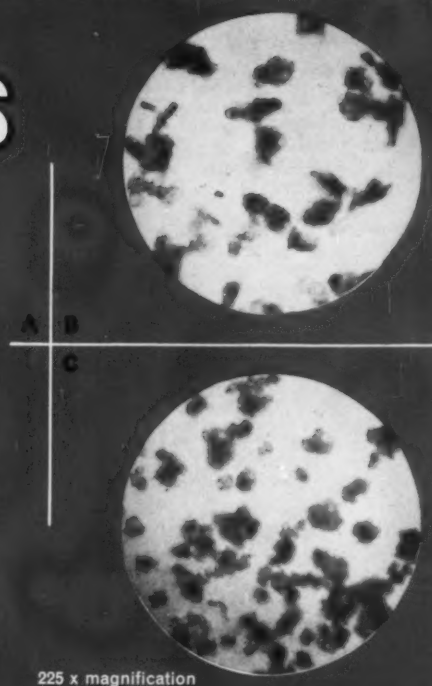
Circle 604 on Page 48-A

INTRODUCING

FLEXICHEM CS

...BY SWIFT





225 x magnification
Scale 1 mm = 4.4 microns

The photo micrographs indicate how FLEXICHEM CS (A) compares in size and uniformity to typical samples of commercially available 325-mesh calcium stearates (B and C).

New, extra fine calcium stearate promotes surface coverage

FLEXICHEM CS is a new impalpable calcium stearate of such fine particle size that it defies measurement by usual screening methods. Its average particle size is 5 to 7 microns while maximum size will range to only 20 microns.

For producers of powder metal parts, this unique property can spell greater surface coverage and improved lubricity for every pound of FLEXICHEM CS used. For users of resin coated sand, FLEXICHEM CS may be used as a mold release agent, to promote improved flowability, or as an internal lubricant.

In addition, FLEXICHEM CS contains less than 0.6% moisture, is extremely low in water soluble salts, and has less than 0.2 PPM of combined arsenic and lead. Look over its other properties on the chart—then write for details on a trial or sample quantity of Swift's new FLEXICHEM CS.

FLEXICHEM is Swift's trade name for a new family of "light" metallic complexes made possible by a new simplified reaction process. The benefit of Swift's development experience in utilizing these new stearates is available to serve you. *Write for details.*

SWIFT & COMPANY
SOAP DEPARTMENT
4115 Packers Ave. Chicago 9, Illinois

FLEXICHEM CS

GENERAL PROPERTIES

Type of salt:	Di
Physical form:	Impalpable powder
Particle size:	20 microns maximum
Color:	White
Formula:	$Ca(C_{18}H_{35}O_2)_2$
Odor:	Bland
Bulk density:	20 lbs. per cu. ft.
Melting point:	147°-149° C.
Moisture:	0.6%
Iodine number:	2 maximum
Solubility:	Insoluble in water, alcohols, esters and ketones. Slightly soluble in hot benzene, toluene, xylene, carbon tetrachloride, vegetable and mineral oils. Soluble in hot pyridine.

For further details, write for Bulletin 42.

Swift

105TH YEAR

S-44R

To Serve Your Industry Better

Circle 480 on Page 48-A

347. Salt Bath

NU-SAL is described in Technical Bulletin H-2. It is suitable for heat treating steel and for silver soldering. With carbonaceous cover it can operate for short periods up to 1800° F. *Park Chemical Co.*

348. Dryers

12-p. bulletin includes six case histories of difficult drying operations solved by properly engineered equipment. *J. O. Ross Engineering Div.*

349. Salt Bath Furnaces

New designs for gas heated or oil heated salt bath furnaces; temperatures up to 2300° F. Bulletin 200. *Ajax Electric Co.*

350. Tempilstiks

Catalog 5905 gives directions for use and temperature ratings of the various Tempilstiks, Tempilags, and Tempil Pellets. *Tempil Corp.*

351. Ultra-Temp. Ovens

Bulletin 6950 describes line of electric ovens for operating up to 1300° F., capacity range 1 to 36 cu.ft. *Blue M Electric Co.*

352. Liquid Salt Baths

The "Houghton Line"—an occasional booklet mixes philosophy and humor with information on heat treating in salt baths. *E. F. Houghton & Co.*

353. Flame Hardening

Bulletin tells how flame hardening improves rolls; accompanying chart for depth of hardening. *Detroit Flame Hardening*

354. Ammonia Atmospheres

8-p. booklet on industrial uses of dissociated ammonia (bright hardening and annealing, brazing, powder sintering). *Armour Ammonia*

355. Temperature Uniformity

"A Study of Temperature Uniformity in Heat Treating" gives time-temperature curves for various runs to 1550 and 1850° F. with still and circulating atmospheres. *Ipsen Industries, Inc.*

356. Quenching Systems

Combined catalog and selection manual for quenching oil coolers. Completely self-contained units with motors, strainers and all controls. *Bell & Gossett Co.*

357. Strand Annealer

Bulletin 653A describes electrically-heated strand annealing furnaces, handling brass or bronze wire at 22,000 ft. per min. Dissociated ammonia atmosphere. *Hevi-Duty Electric Co.*

358. Annealing Aluminum Sheet

Literature available on high-convection, bell-type furnace which successfully anneals large coils of aluminum sheet as thin as 0.025 gage without damage to edges. *Lee Wilson Engineering Co.*

359. Endothermic Generator

Bulletin 5808A gives the facts about "Type IGL" generators for accurate production of atmosphere of selected carbon potential, "carbon pressure" and low dewpoint. *C. I. Hayes*

360. Continuous Furnaces

For small parts, both rotary muffle and shaking hearth, automatically fed, up to 800 lb. per hr. Catalog from *American Gas Furnace Co.*

361. Blowers

Catalog 126B describes blowers for a variety of large heating furnaces such as slab reheaters, annealing covers and soaking pits. *Spencer Turbine Co.*

363. Induction Heating

56-p. catalog describes complete line of induction heating equipment for hardening, brazing, billet heating, sintering and shrink fitting. *Induction Heating Corp.*

364. Thermal Fatigue

A comprehensive report of extensive studies on "The Mechanism of Thermal Fatigue"—damage from numerous cycles of heating and cooling. *Electro-Alloys Div.*

365. Radiant Tubes

Light-weight, prefabricated tubes, straight, U-bends, parabolic, with smooth interiors described in booklet "Processes and Heat Treating Equipment". *Pressed Steel Co.*

366. Furnace

Recirculating type of furnace operating up to 1200° F. for drawing, tempering, aging and stress relieving. Bulletin HT-53. *Carl Mayer Corp.*

Cleaning & Finishing

369. Metal Shot

Brochure entitled "The Facts of Life Concerning the Use of Shot and Grit". Five chapters. *National Metal Abrasive Co.*

370. Descaling Salt

Literature describing rapid descaling (10 min.) of stainless steel tubes with the help of "Virgo Descaling Salt". *Hooker Chemical Corp.*

371. Ultrasonic Cleaning

Reprint of article "Ultrasonics—an Outstanding Aid to Metal Cleaning". *Detrex Chemical Industries*

372. Selective Plating

Brochure describes power pack, plating tools and solutions for building up worn areas, stopping-off prior to carburizing, or fitting bearings. *Stfco Metachemical, Inc.*

373. Low-Cost Plating

Technical data available in "B & A" metal fluoborates for electrolytes depositing fine-grained Cu, Pb, Pb-Sn alloy, Ni and Sn. *General Chemical*

374. Chromate Conversion Coatings

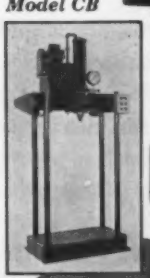
Booklet "Process Chemicals" describe the "Iridite" specialized line of chromate conversion coatings for nonferrous metals — dip, brush or spray—manual or automatic. *Allied Research Products*

Faster Testing

with a long-stroke Brinell machine

Model DHL

Model CB



Faster hardness testing is yours when you use a Detroit long-stroke testing machine. The long-stroke test ram does the adjusting to various work piece heights, and does it fast. Constant height table always matches conveyor height, too. Hydraulically operated, with or without direct reading dial (shown with). Larger and special machines made to order.

Write today for information about our Brinell and other testing machines

DETROIT TESTING MACHINE COMPANY

9384 Grinnell Avenue, Detroit 13, Michigan

Circle 608 on Page 49-A

QUICK COMPARISON CHART

Some unique combinations of electrical and physical properties in Anaconda metals that may save you money—handle tough jobs better

Properties shown for precipitation-hardened condition—Heat-treatable alloys	ELECTRICAL CONDUCTIVITY % IACS	TENSILE STRENGTH psi	YIELD STRENGTH at 50% ext. under load, psi	ELONGATION % in 2 in. or 4xD	MACHINABILITY compared with F.C. Brass at 100	FORMS AVAILABLE
Chromium Copper-999 (Cu 99.05%, Cr .85%, Si .10%)	75	65,000	55,000	20	20	Rod Wire Tube Forgings Strip
Leaded Nickel Copper-831 (Cu 97.8%, Pb 1.0%, Ni 1.0%, P .2%)	55	80,000	70,000	7	80	Rod
Cunisil-837 (Cu 97.5%, Ni 1.9% Si .6%)	30 to 42	90,000	70,000	8	40	Rod

To give you a basis of comparison, here are properties of two standard Anaconda electrical coppers

ETP Copper—100 (Cu 99.9+%)	100	48,000	40,000	15	20	All mill forms
Leaded Copper—126 (Cu 99.0%, Pb 1.0%)	98	48,000	40,000	12	80	Rod bar

The values given above are intended as a guide to some unusual combinations of electrical and physical properties available among Anaconda alloys. If any of them gives you an idea for possible solution to a tough problem or indicates a way to cut costs without sacrificing quality or performance — see your American Brass representative for more details. Or send in this coupon today.

8949

COPPER • BRASS • BRONZE • NICKEL
SILVER MILL PRODUCTS

ANACONDA®

PRODUCTS

Made by The American Brass Company

The American Brass Co., Waterbury 20, Conn.
In Canada: Anaconda American Brass Ltd., New Toronto, Ont.

Please send me more information about the following alloys:

- ☐ Chromium Copper—999
- ☐ Leaded Nickel Copper—831
- ☐ Cunisil—837
- ☐ Leaded Coppers
- ☐ Electrolytic Tough Pitch Copper—100

Name.....

Company.....

Street.....

City.....Zone.....State.....

Circle 481 on Page 48-A

378. *Protective Coating*

"EP-ACK" is a protective and decorative coating which rapidly dries in air, has good toughness and adhesion and is light fast. *Industrial Finishes Co.*

379. *Protective Paint*

"New Color Horizons" is a 38 p. manual of a rust and corrosion control by protective coatings. Also contains information on surface preparation. *Rust-Oleum Corp.*

380. *Rust Preventives*

Bulletins describe two new formulations. "Composition 15" added to rinse water to prevent rusting of iron castings and powder compacts, and "Composition DR" added to rinse water to facilitate drying. *Mitchell-Bradford Chemical Co.*

381. *Solution Control Valves*

"Monotrol" 4-way valves in either cast iron or plastic to control liquid flow in such series of operations as service, backwash, regenerate and rinse. *Graver Water Conditioning Co.*

Welding and Joining

383. *Resistance Welding*

Sciaky Bros., Inc., publish a monthly bulletin called "Resistance Welding at Work". The latest issue contains five case histories taken from the aviation industry.

384. *Electrodes*

8-p. folder describes economies in using special electrodes for excavating machinery, hard surfacing and stainless steel. *The McKay Co.*

385. *Preheat for Weldments*

40-p. "Guide to Preheat" describes use of electric strip heaters, assembled from standardized re-usable units. *J. B. Nottingham & Co.*

386. *Stainless Electrodes*

Folder describes 20 electrodes for joining standard stainless steels and high-strength steels. *Harnischfeger Corp.*

387. *Feedback Spot Welding Control*

Bulletins showing how "Monautronic V-2 and VR-3" circuitry keeps the voltage constant across resistance weld, despite variable resistance due to electrode wear and pressure, contaminants and gage. *The Budd Co.*

388. *Brazing Alloy*

Data on "Braze 541", a silver-copper alloy especially suitable for stainless steels and Monel metal, either with hand torch or in furnace. *Handy & Harman*

389. *Buttwelder*

Reprint of "Buttwelder Leaves No Flash", with Tocco induction heating unit and Swift-Ohio press mechanism, *Ohio Crankshaft Co.*

390. *Hard Facing*

28-p. booklet describes machinery for hard-facing metallic parts. Five different welding methods are suitable. *Haynes Stellite Co.*

Inspection & Control

391. *Testing Machinery*

Loading of large pieces can be done by numerous movable hydraulic rams all controlled from central pump and indicator units. *Riehle Testing Machines*

392. *Proportioning Control*

Literature descriptive of proportioning control systems assembled for specific installations have standard units of three types—current output, position or duration. *Barber-Colman Co.*

393. *Thermocouples*

Catalog of standard thermocouples sheathed in various heat resisting metals, hot junctions. leads and terminal blocks. *Conax Corp.*

394. *Pyrometers*

Catalog No. 100 on radiation pyrometers with ranges from 1000 to 3400° F. *Pyrometer Instrument Co.*

395. *Strain Gages*

Pamphlet on "Tatnall Metal Film 102" strain gages usable to 400° F., showing configurations, (comb, rosette and miniature) available. *The Budd Co.*

396. *Brinell Testing*

Information available about power-operated machine, controlled by foot pedal, that requires no preliminary spot grinding of parts to be tested. *Detroit Testing Machine Co.*

397. *Microscopes*

Catalog 2-Y describes complete line of metallurgical microscopes, camera attachments, micrometers, vacuum heating stages. *Unitron Instrument Division*

398. *Metallographs (Remote Control)*

Manual D-287 describes equipment for examining and photographing radio-active materials using double eye pieces (stereo-microscopes with lenses resistant to coloration from radiation). *Bausch & Lomb Optical Co.*

399. *Rockwell Testers*

Catalog RT-58 gives information on full line of Rockwell hardness testers, Tukon micro-testers, "Twin-testers" (manual and automatic). *Wilson Mechanical Instrument Div.*

400. *Multi-Point Recorder*

Model 6702 can record up to 24 and has many simplified features. A solid-state constant current source eliminates standard cells and standardizing mechanisms. *Daystrom-Weston*

401. *Thermowells*

Application Guide E-16 describes 5700 available designs of thermowells, each pressure tested to 3000 psi. (X-rayed if specified). *Thermo Electric Co.*

402. *Spectrograph*

Booklet entitled "Introduction to Optical Emission Spectrochemical In-

NEW KENTRALL HARDNESS TESTERS are Motorized

By removing major test loads automatically, the new motorized Kentralls reduce operator error, increase reproducibility of test results, and raise the productive capacity of the machine—for the same price as hand operated testers.

The motorized Kentralls are available in Combination Testers which provide both Regular and Superficial Rockwell Hardness Testing in a single machine. For those applications that do not require the additional range, Kentrall also makes single purpose testers for either Regular or Superficial testing alone.

For complete information write for Bulletin CRS 60

KENTRALL THE TORSION BALANCE COMPANY
Main Office and Factory: Clifton, New Jersey
Sales Offices: Chicago, San Francisco

TB163

Circle 605 on Page 48-A

Results

from pilot installation sell Youngstown Sheet and Tube complete 40-furnace Lee Wilson single stack annealing system

Two years ago Youngstown Sheet and Tube installed a pilot single stack annealing operation consisting of six furnaces and 18 bases. Today, after carefully compiling quality-economy comparison records, they have on order a complete Lee Wilson single stack annealing installation of 40 furnaces and 120 bases.

Outstanding results . . . that's what has made the Lee Wilson single stack furnace the most popular method of annealing whereever steel is made.

At Youngstown Sheet and Tube much of the comparison was made on 100 percent drawing quality steel where uniformity of anneal is an absolute necessity.

For uniformity and quality—for speed and flexibility—for economy under any operating condition—nothing beats the Lee Wilson single stack annealing furnace. That's why over 600 of them are in use today all over the world!

Lee Wilson® ENGINEERING COMPANY, INC.

HIGH PRODUCTION ANNEALING SYSTEMS

MAKE THE BEST METALS BETTER

ORIGINATORS AND LEADING PRODUCERS OF OPENED COIL AND SINGLE STACK FURNACES

Circle 482 on Page 48-A

struments" describes among others a direct reading spectrograph—a precision time-saver. *Baird-Atomic, Inc.*

403. Laboratory Furnaces

Booklet "Marshall High-Temperature Furnaces" describes complete line of tubular furnaces, resistance wound to operate up to 2600° F. *Marshall Products Co.*

404. Metallograph

Brochure entitled "Laboratory Workhouse" describes metallograph with automatically focussing screen directly below eyepieces. *American Optical Co.*

405. Ultrasonic Inspection

Branson Instruments, Inc. have published Bulletin T-203 about the Pulse-Echo "Sonoray" flaw detector for contact or immersed use. It has an infinite choice of frequencies between 0.4 to 10.0 m.c. per sec.

406. Portable Hardness Tester

Various sizes and designs of portable hardness testers, adapters, holddowns and scanning arms described in literature by *King Tester Corp.*

407. Optical Pyrometer

Catalogs No. 85 and 100 describe optical pyrometer (range 1400 to 7500° F.) and radiation pyrometer (range 1000 to 3400° F.). No accessories required. *Pyrometer Instrument Co.*

408. Carbon Analyzer

16-p. catalog describes compact equipment for analyzing metals in 2 min. for carbon and sulphur. *Harry W. Dietert Co.*

409. Particle Inspection

Booklet describing agent for wet magnetic particle inspection. Case histories compare special methods and their effectiveness. *Harry Miller Corp.*

410. Polishing Cloths

Vol. 5, No. 3 of "A.B. Metal Digest" is devoted to polishing cloths and abrasives for preparation of metallographic specimens. *Buehler Ltd.*

411. Protective Equipment

Broadside describes 13 types of environmental test chambers—explosion proof, altitude chambers, salt spray equipment and the like. *Associated Testing Laboratories, Inc.*

412. Leak Testing

Detectors for testing tightness of smaller pressurized containers, suitable for a single probe for boxed containers or for hooded conveyors. Bulletins GET-3026 and 2935. *General Electric Co.*

413. Specimen Mount

Folder describes rapidly-setting plastic slurry for preparing metallographic specimens. *Vernon-Benshoff Co.*

414. Dilatometers

Chevenard dilatometers, recording either mechanically or photographically in vacuum or controlled atmospheres. *Cooke, Troughton & Simms, Inc.*

415. Laboratory Furnace

Bulletin No. 315 describes small furnace operating up to and above 2000° F. for heat treating, sintering and melting.—*Burrell Corp.*

416. Timers

Type TSA-14 process timer controls repetitious cycles, where amount of "on time" is adjustable. *General Electric Co.*

417. Gamma Radiography

Pamphlet describing line of 16 machines using various quantities of iridium 192 and cobalt 60, for beam or for panoramic radiography. *Radiation Engineered Services*

Fabrication Equipment

418. Induction Stirrers

Illustrated booklet on electrical attachment to bottom of arc furnaces to stir molten metal during refining. *ASEA Electric Inc.*

419. Vacuum Furnaces

Various sizes of furnaces, pumps and accessories for melting and casting heats ranging from 15 to 500 lb. in vacuum down to 1 micron. *Kinney Div. of New York Air Brake Co.*

420. Vacuum Pumps

16-p. Bulletin 8-20 describes modern change of old Roots blower into an efficient vacuum pump. Operating characteristics and proper speeds for various vacuums. *Consolidated Vacuum Corp.*

421. High-Vacuum Furnace

Bulletin describes "VA-L-200H" Heraeus vacuum arc furnaces, ranging in size from 250-cu.in. crucible to 6600 lb. capacity. *Consolidated Vacuum*

422. Ingot Molds

For use in vacuum melting equipment or in controlled atmosphere. Molds of fabricated steel, graphite or water-jacketed copper. *Zak Machine Works, Inc.*

423. Strip Mills

Full details of all-purpose strip mills, 2-high or 4-high, for conventional purposes and for rolling metal powders into commercial strip. *Stanat Mfg. Co.*

424. Tube Mills

88-p. book on tube mills describes equipment for converting strip continuously to welded tubing of either ferrous or nonferrous alloys in sizes from 0.25 to 26 in. *The Yoder Co.*

425. Press Brakes

28-p. Bulletin 89E describes modernized line of machinery of capacity 90 to 1500 tons. Also tables for computing tonnages, and die space and filler dimensions. *Niagara Machine & Tool Works*

426. Wire Straightener

"Motomatic" wire straightening and cutting machine (synchronized flying shear cuts off accurate lengths) described in Bulletin 751. *Vaughn Machinery Co.*

SELECTIVE PLATING

Production and Repair Plating
without using immersion tanks

Enables You to (1) Precision-plate selected areas economically —without disassembling components; (2) Deposit metals rapidly where conventional electro-plating is impossible or difficult. Mobile equipment takes the process to the job.

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D & S AVIATION CO., LTD. 671 Laurentides Blvd. Pont Viau, Montreal, Quebec

Circle 609 on Page 48-A

KNOW YOUR ALLOY STEELS . . .
This is one of a series of advertisements dealing with basic facts about alloy steels. Though much of the information is elementary, we believe it will be of interest to many in this field, including men of broad experience who may find it usefu to review fundamentals from time to time.

Quenching and Tempering Alloy Steels

Of the various methods of heat-treating alloy steels, one of considerable importance is that involving quenching and tempering. This method, which enhances the mechanical properties of the end product, differs materially from normalizing and annealing (previously discussed in this series).

The purpose of quenching is to effect a cooling rate sufficient to develop the desired hardness and structure.

Before quenching takes place, steel is heated to a point above the transformation range. Quenching is the subsequent immersion of this heated steel in a circulated or agitated bath of oil, water, brine, or caustic; or, in the case of austempering or martempering, generally in agitated molten salt baths at a prescribed temperature. Austempering and martempering are preferable where a minimum of distortion is desired.

Quenching *increases* the tensile strength, yield point, and hardness of alloy steels. It *decreases* ductility —that is, elongation and reduction of area. It also decreases resistance to impact. However, by means of tempering, it is possible to restore some of the ductility and impact-resistance—but only at a sacrifice of tensile strength, yield point, and hardness.

The results of mild oil- or water-quenching as related to mass effect can be found in the end-quench hardenability test. Voluminous data concerning this test are issued by AISI and SAE in the form of hardenability bands for the various grades of alloy steels.

If thermal cracking is to be avoided, cooling by liquid quenching should not be carried to a point below 150 deg F. When a temperature of 150 deg F is approached, immediate tempering should follow. Because of residual stresses, no steel should be used in the as-quenched condition.

Tempering can be defined as reheating to a specified temperature below the lower critical range, followed by air cooling. It can be done in furnaces, oil, or salt baths, the temperatures varying from 300 to 1200 deg F. With most grades of alloy steel, it is best to avoid temperatures between 500 and 700 deg because of the "blue brittleness" that occurs in this range. Maximum hardness and wear-resistance result from tempering at low temperatures; maximum toughness is achieved by tempering at the higher levels. Of course, one of the essential reasons for tempering is to relieve the residual stresses set up in quenching.

Bethlehem metallurgists have devoted years of study to all phases of heat-treating. By all means call them if they can be of service to you. And please remember, when you are next in the market for alloy steels, that Bethlehem makes all AISI standard grades, as well as special-analysis steels and the full range of carbon grades.

BETHLEHEM STEEL COMPANY
BETHLEHEM, PA.

Export Distributor:
Bethlehem Steel Export Corporation

BETHLEHEM STEEL

BETHLEHEM STEEL

Circle 569 on Page 48-A

Metal Parts & Shapes

427. *Shaped Alloy Wire*

Various nickel and stainless alloys are available in squares, flats, triangles, hexagons, half-rounds. Their applications are listed. *Riverside-Alloy Metal Div. of H. K. Porter Co.*

428. *Alloy Castings*

20-p. Bulletin G-159 describes Alloy Casting Institute's standard heat and corrosion resistant analyses, and also new alloy "HOM" for use up to 2300° F. *The Duraloy Co.*

429. *Mechanical Bearings*

16-p. bulletin describes line of bearings intermediate in design between ball bearing and roller bearings wherein the rollers have curved elements conforming to the spherical surface of the outer raceway. *Hoover Ball & Bearing Co.*

430. *Forgings & Stampings*

6-p. folder illustrates parts for heavy road-building and earth-moving equipment. *Transue & Williams Steel Forging Corp.*

431. *Malleable Iron*

Data on automotive uses of malleable iron castings to save weight, gain strength and save machining costs. *Malleable Castings Council*

432. *Forgings*

Booklet "The Automatic Production of Forgings in Closed Dies". *Chambersburg Engineering Co.*

433. *Die Cast Gears*

List of gear and pinion combinations die-cast in zinc alloys from interchangeable unit die system molds to AGMA standards. *Gries Reproducer Corp.*

434. *Wire Cloth*

94-p. catalog describes industrial wire cloth made in nine basic weaves in a wide variety of metals and alloys, including titanium. *Cambridge Wire Cloth Co.*

435. *Sandwich Construction*

45-p. brochure on design, construction and use of various types, attachment and edge details, and design formulas. *Hexcel Products, Inc.*

436. *Seamless Tubing*

Technical Data Folder 193 discusses advisability of standardizing on two general-purpose alloys (S.A.E. 4340 and 4620) for manufacture of tubular parts. *Babcock and Wilcox Co.*

437. *Bimetallic Castings*

8-p. brochure on bimetallic casting. Applications, design data. *Arthur Tickle Engineering Works*

438. *Stainless Tubing*

Complete information is available about "Weldrawn PH 15-7 Mo" tubing. The steel is precipitation hardening. Tubing available in sizes from 0.012 to 1.125 in. *Superior Tube Co.*

439. *Textured Steel*

"Sharonart" (steel sheet stamped or impressed with any one of a variety of patterns) has many advantages to the manufacturer of consumer items of beauty and durability. Bulletin by *Sharon Steel Corp.*

440. *Welded Tubing*

Pamphlet describes uses of "Electrunite" welded mechanical tubing of high tolerance in straightness, wall thickness, inside and outside diameter. *Republic Steel Corp.*

441. *Aluminum Tubing*

48-p. book on alloy tubing, its properties, selection and applications. *Revere Copper & Brass*

442. *Butterfly Valves*

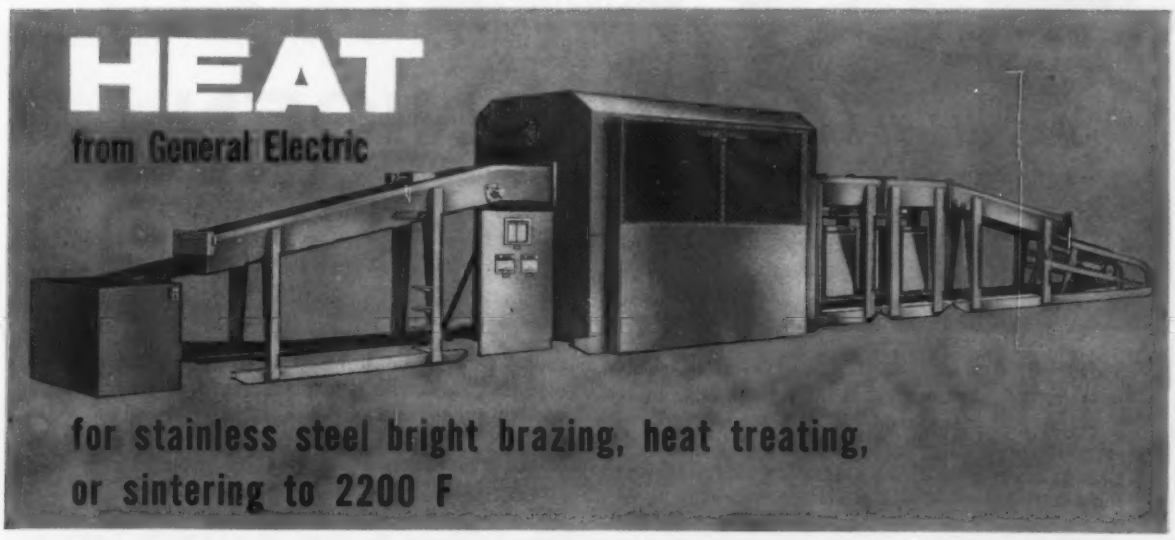
36-p. catalog of iron-body, rubber-seated valves for hydrostatic pressures up to 125 psi. and operated manually or by various automatic systems. Suitable for liquid, gas and vacuum. *Pelton Div. of Baldwin-Lima-Hamilton Corp.*

443. *Shims and Gaskets*

Color code whereby thickness of "Color-plast" gaskets and packings, ranging from 0.001 to 0.030 in., is identified by sight. Many mistakes thus avoided. *General Gasket, Inc.*

444. *Extruded Aluminum*

12-p. brochure on latest aluminum alloys, extrusion process and applications. *Precision Extrusions, Inc.*



NEW Muffle-less Mesh-belt Furnace from General Electric maintains high purity atmosphere and high temperature needed to treat stainless steel parts in continuous production. Performance is excellent: dewpoints of below −50 F have been maintained under production conditions. Rapid heating, high heating rates, maximum loading add up to increased production. Your operating costs are less because of reduced heat loss and cooling water, fewer rejects, hydrogen conservation. Key to reduced maintenance is there's *no muffle to replace.* Other factors: long-life belt and molybdenum heating units; easily cleaned cooling chambers.

Circle 606 on Page 48-A

Ask your General Electric Sales Engineer for complete data on the new G-E Hump Mesh-belt Furnace or write for bulletin GED-3990. General Electric Company, Schenectady 5, N. Y.

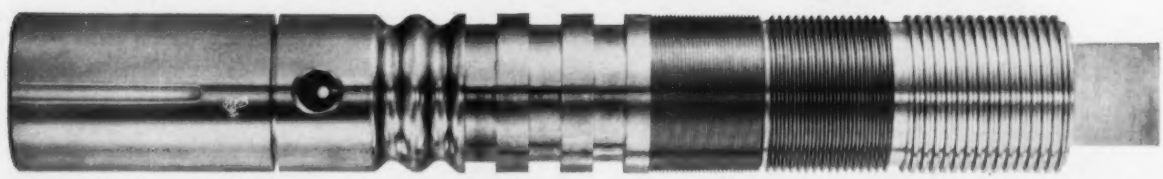
721-28

Progress Is Our Most Important Product

GENERAL ELECTRIC

THEY LAUGHED WHEN WE SAT DOWN TO PLATE...

they didn't know about **KANIGEN®**



This shaft was turned. It was key-slotted, drilled, tapped and shouldered. It was threaded, milled, grooved and chamfered. It was step-bored, with three inside diameters. Who could plate a piece like this all over—inside and out—and expect a uniform coating?

Well, anyone who used KANIGEN® could expect it—and get it. In fact, we made this piece especially to prove it.

The KANIGEN® process for chemical nickel alloy plating produces a uniform thickness of coating, regardless of the contours of a part. This uniformity permits full machining operations prior to coating, with no subsequent cleanup.

KANIGEN® offers corrosion resistance equal or superior to that provided by wrought or electrolytic nickel.

For complete technical details write or call your nearest General American office. Ask for Kanigen Bulletin No. 258. You'll find that with plating as in so many other industrial areas, *it pays to plan with General American.*

Kanigen Division

GENERAL AMERICAN TRANSPORTATION CORPORATION

135 South LaSalle Street • Chicago 3, Illinois

Offices in principal cities

KANIGEN GENERAL AMERICAN TRADE MARK

Circle 483 on Page 48-A

If you are looking for

HEAT RESISTANT
A.C.I.
HA, HC, HD, HE, HF, HH, HI, HK, HL, HN, HT, HU, HW, HX

STAINLESS
A.C.I.
CA-15, CA-40, CB-30, CC-50, CE-30, CF-8, CF-20, CF-8M, CF-12M, CF-8C, CF-16F, CH-20, CK-20

Castings

LOOK NO FURTHER THAN fahralloy

For over a quarter of a century Fahralloy has served the needs of the nation's leading industries with highest quality alloy castings. Whether your particular need is for heat resistant alloy castings or stainless, you can be sure they'll be made to your exact specifications when you place your order with Fahralloy.

- TUBES
- TRAYS
- RETORTS
- BASKETS
- FIXTURES
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150TH AND LEXINGTON AVENUE • HARVEY, ILLINOIS

QUALITY • SERVICE • INTEGRITY

Circle 484 on Page 48-A

How B&W JOB-MATCHED TUBING helps you design a better end product

You can get the right tube for your job with B&W Seamless Mechanical Tubing because you can choose from:

- ...a range of sizes, grades, and finishes for design flexibility
- ...a variety of heat treated conditions for the most suitable mechanical properties
- ...special shapes and prefabricated forms to improve design and simplify production.

These are just some of the reasons it pays to specify B&W Job-Matched Mechanical Tubing. Call your local B&W District Sales Specialist, or write for Bulletin TB-361 for full information. The Babcock & Wilcox Company, Tubular Products Division, Beaver Falls, Pennsylvania.

B&W

THE BABCOCK & WILCOX COMPANY

TUBULAR PRODUCTS DIVISION

TA-9009-SM4

Seamless and welded tubular products, solid extrusions, seamless welding fittings and forged steel flanges—in carbon, alloy and stainless steels and special metals

Circle 485 on Page 48-A

New! Complete Reader Service Information With These Convenient, Prepaid Cards

Catalogs and bulletins, new products and services and most advertisements in Metal Progress are numbered. To receive more information, circle the appropriate numbers on one of these postage paid cards. Editorial reprints will be sent free as long as they last.

Catalogs and Bulletins, are available from a *scrutinized* list of manufacturers' literature, conveniently indexed under the 11 major Engineering Areas.

More Facts on Advertised Products. Because some advertisements cannot be numbered, please write those advertiser's names in the blanks provided.

New Products and Services are numbered. Circle the postcard for more information.

Reprints of Articles are yours for the asking as long as they last. No need to clip your Metal Progress issue for reference filing, send for reprints.

Please Include Your Name and Address!

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Metal Progress

February, 1960 Issue

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February, 1960 Issue
METAL PROGRESS

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METAL PROGRESS
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NOVELTY, OHIO

The American Society for Metals and Metal Progress Serves 30,000 member-readers in 11 major areas of the metals industry.

The ASM is the communications center for technical information wherever metals are produced, processed, fabricated, designed, tested and applied. Metal Progress, monthly engineering magazine of the Society, reports on engineering developments in these 11 major technological areas:

FERROUS METALS: Alloy, Carbon, Free Machining, Stainless Steels, Hot and Cold Finished Bars.

NONFERROUS METALS: Aluminum, Beryllium, Brass, Bronze, Columbium, Copper, Lead, Magnesium, Molybdenum, Monel, Nickel, Rare Earths, Tantalum, Titanium, Tungsten, Zinc, Zirconium.

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TOOL MATERIALS, CUTTING AND FORMING EQUIPMENT: Abrasives; Carbides; Coolants, Oils and Lubricants; Arc and Gas Cutting Equipment, Saws; Forging, Pressing, Extruding Chemical Milling, Slitting, Straightening and Spinning Equpment; Tool and Die Steels, Plastic and Other Short-Run Die Materials.

INDUSTRIAL HEATING EQUIPMENT AND SUPPLIES: Atmosphere Generators and Gases; Commercial Services; Furnaces; Controls, Indicators and Recorders; Induction, Flame and Salt Bath Equipment; Ovens; Pyrometers; Quenches; Samplers and Analyzers; Trays, Refractory Parts.

CLEANING AND FINISHING EQUIPMENT AND SUPPLIES: Alkaline Cleaning, Pickling, Degreasing, Buffing, Polishing, Blasting, Plating, Porcelain Enameling, Purifying, Painting Equipment and Supplies; Rust Preventives; Abrasives.

WELDING AND JOINING EQUIPMENT AND SUPPLIES: Gas, Resistance and Arc Welding Equipment and Supplies; Electrodes; Adhesives, Fasteners; Hard Surfacing, Brazing and Soldering Equipment and Supplies.

INSPECTION AND CONTROL EQUIPMENT AND SUPPLIES: Microscopes and Attachments; Analytical and Mechanical Equipment; Gages, Comparators, Hardness Testers, Nondestructive, Electronic and Other Scientific Inspection Equipment.

PRODUCTION AND CASTING EQUIPMENT AND SUPPLIES: Electric and Vacuum Melting Furnaces; Refractories; Ferro Alloys; Foundry Irons and Coke; Rare Earths; Alloying and Refining Agents; Annealing, Soaking and Sintering Furnaces; Rolling Equipment; Industrial Gases; Foundry Equipment and Supplies.

PARTS, FORMS AND SHAPES FOR DESIGN AND APPLICATIONS: Castings (Malleable, Gray Iron, Steel, Non-Ferrous), Forgings, Extrusions, Powder Metal Parts, Springs, Stampings, Tubings, Weldments, Wire.

February, 1960 Issue
METAL PROGRESS

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NOVELTY, OHIO

BUSINESS REPLY CARD
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Metal Progress

February, 1960 Issue

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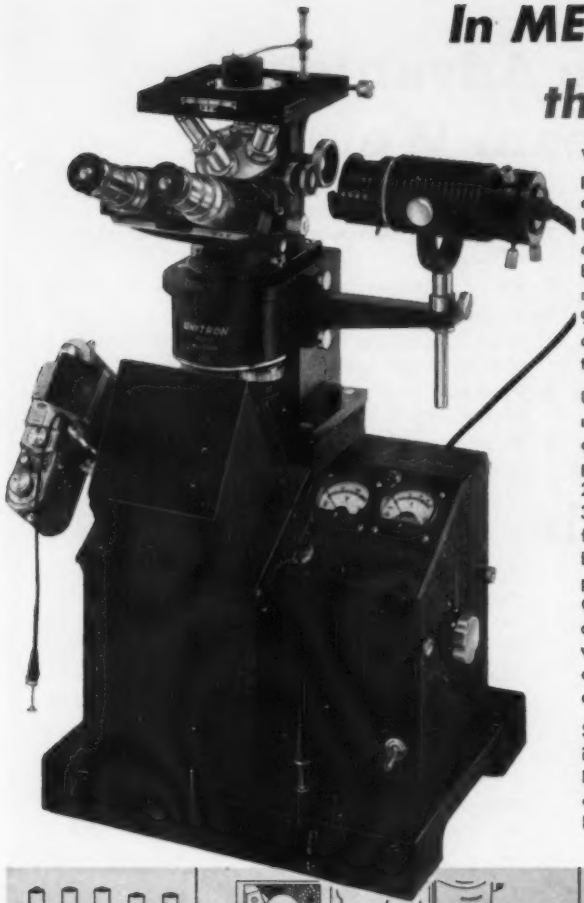
In METALLOGRAPHS...

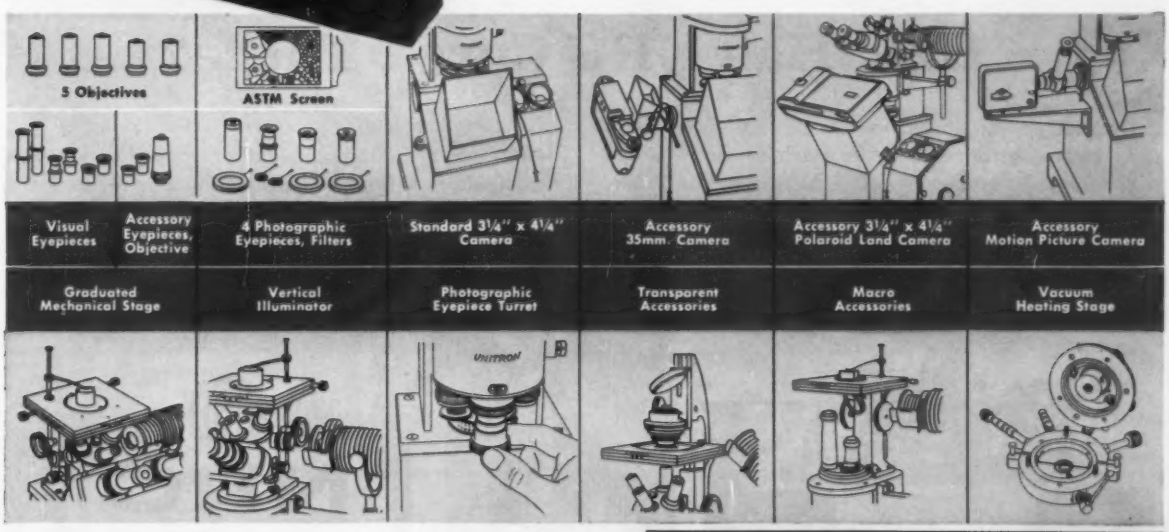
the trend is to UNITRON!



What do you look for when choosing a metallograph? All of the popular makes are precision instruments, are reasonably versatile and, to a varying degree, are easy to operate. But, except for UNITRON, all have the bulk of an office desk or optical bench and are tagged with a price that puts a substantial dent in the laboratory budget. UNITRON, and only UNITRON, offers a completely equipped metallograph in a compact and self-contained unit, taking only 9" x 12" of table space, which duplicates the performance of large cumbersome instruments — and at a price which is hardly more than the usual cost of a conventional metallurgical microscope.

Unlike the case with most metallographs, an adding machine is not required to compute its cost. Coated optics supplied as standard equipment include 5 objectives, 4 photographic eyepieces and 3 pairs of visual eyepieces. These give a magnification range of 25X-2000X. Also included in the purchase price are the built-in 3¼" x 4¼" camera and viewing screen; high-intensity illuminator for vertical, oblique, and transmitted light; variable transformer with both voltmeter and ammeter; accessories for transparent specimens; polarizing apparatus; filters; film holders; stage clips; cabinets etc. Optional extra accessories include Polaroid Land, 35mm. and movie camera attachments; low power (5X-40X) objectives for macro work; vacuum heating stage for temperatures to 1100°C and long working-distance 40X objective; ASTM Austenite grain size viewing screen and eyepieces; filar micrometer eyepiece; and additional optics.

Such a combination of features, versatility, convenience, and value is indeed unique with UNITRON. Little wonder then, that more and more laboratories are choosing UNITRON . . . from the large organization adding another metallograph to its equipment, to the small company buying an instrument for the first time.



FREE 10 DAY TRIAL

UNITRON's Metallograph and Universal Camera Microscope Model BU-11 with binocular eyepiece; objectives: M5X, M10X, M40X, 40X for transmitted light, 100X oil immersion; paired visual eyepieces: R5X, Ke10X Micrometer, Ke15X; photo eyepieces: 10X, 15X, 20X, Micrometer; etc., as described above.

$1379 f.o.b. Boston

Monocular Model U-11 **$1195**

UNITRON

INSTRUMENT DIVISION OF UNITED SCIENTIFIC CO.
204-206 MILK STREET • BOSTON 9, MASSACHUSETTS

Please rush UNITRON's Microscope Catalog 2-Z

Name_____

Company_____

Address_____

City_____ State_____

THE TREND IS TO UNITRON

Circle 486 on Page 48A

What Are the Advantages of Electron Beam Welding?

"Un-weldable" is a word to be used with caution. Dissimilar materials, such as aluminum and steel, can now be fusion welded by electron bombardment. Pieces of widely varying thickness can be joined in a single pass. Foil is easy. And weldments, even of reactive and refractory metals, look and perform almost like a solid piece.

These and other triumphs are possible with electron beam welders because:

1. **Operation under high vacuum prevents contamination, eliminates costs and uncertainties of inert gas.**
2. **There is no electrode to contaminate the work.**
3. **Surface oxides are cleaned up.**
4. **Wide variations in total power and in power concentration are easily made.**
5. **Spot size can be varied from 10 mils to more than 6 inches.**
6. **Depth to width ratios of 2/1 are possible.**

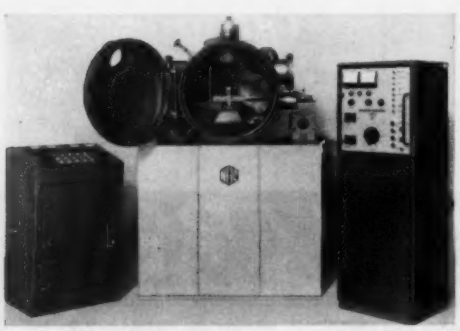
What Have Been the Disadvantages?

In most equipment the electron beam is generated by applying a high voltage between the work and the electron source, with the geometry of the latter focusing the beam. Disadvantages include:

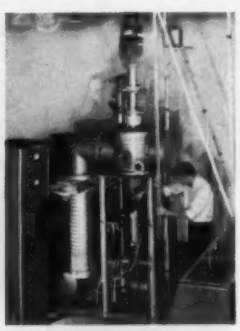
1. **Gas bursts and metallic vapors cause frequent high voltage discharges. At best, these result in annoying interruptions, discontinuous welds, and short source life, and at worst, extensive damage to the equipment. Attempts to reduce discharges by using large vacuum pumping systems and automatic protective devices add greatly to equipment cost and complexity.**
2. **Short focal lengths of ½ to 1 inch pose problems in welding anything but flat pieces and simple cylinders.**
3. **Because the work piece is the anode, the electric field often changes as the weld progresses. This affects the beam and makes precision welding difficult.**

How Has NRC Cured These?

NRC has developed, proved, and applied for a patent on an electron beam welder which is as simple to operate as a television set. It assures complete freedom from high voltage discharges and makes precision welding easy. Work geometry no longer is a problem; even corrugated pieces can be welded successfully. Secret of the NRC Welder's success is its gun design. Special shielding protects the gun against gas bursts and metallic vapors and prevents high voltage discharges. Electro-magnetic focusing makes it easy to change the focal length from 1 to 10 inches and spot size from 10 mils up. Since the area below the gun is field-free, the electron path is unaffected by the shape of the work.



ELECTRON BEAM WELDER Linear or circular welds can be made at speeds of 0 — 0.5 inch per second with the standard Model 2405 Electron Beam Welder. Offered with a choice of 1, 3, or 6 KW power supply, it is easily adapted for end or girth welding.



ELECTRON BEAM FURNACE Reactive or refractory metals can be melted in a standard Model 2460 Electron Beam Furnace to produce ultra high purity ingots up to 3" in diameter and 14" in length. Operation is easy and free from interruption. Special shielding prevents high voltage discharges.

NRC

NRC

EQUIPMENT CORPORATION

A Subsidiary of National Research Corp. — Dept. 1-N
160 Charlemont St., Newton 61, Massachusetts
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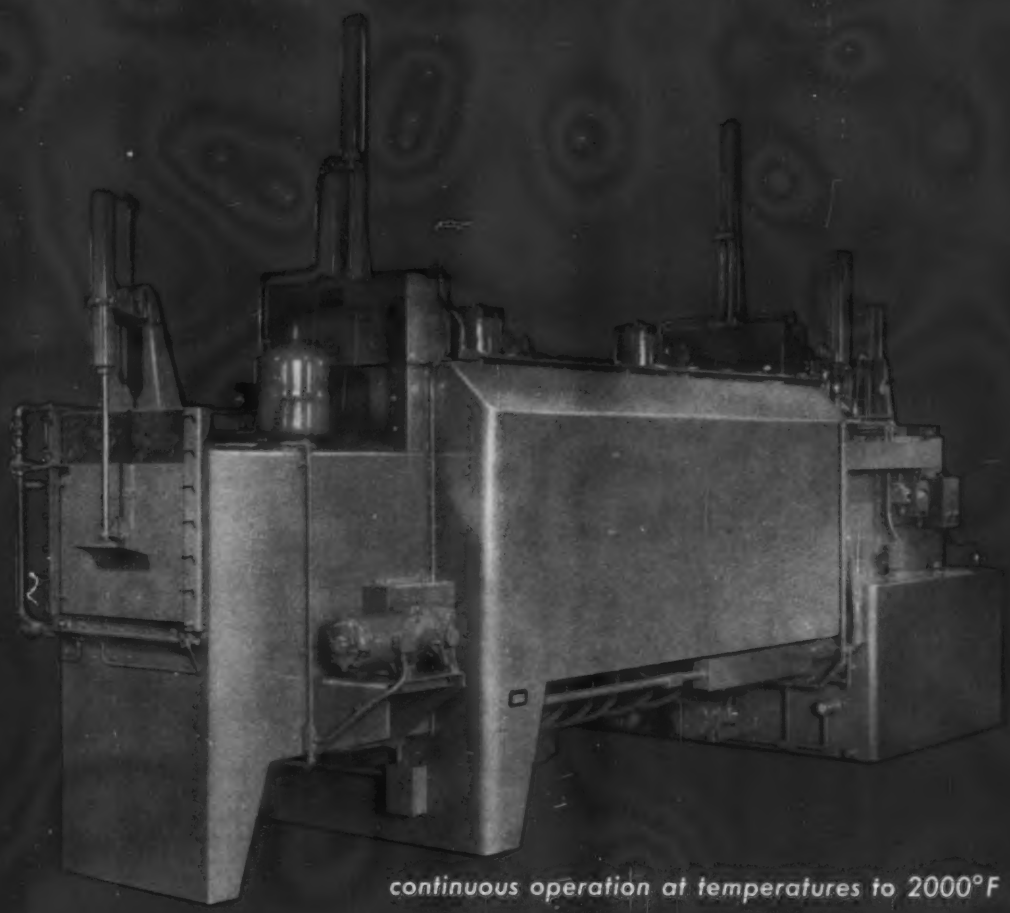
Houston • Los Angeles • New York • Palo Alto • Pittsburgh

Circle 558 on Page 48A

Here's the NEW Ipsen pusher heat treating unit



continuous operation at temperatures to 2000°F

Meets precise metallurgical standards in carburizing, carbonitriding, neutral hardening, sintering, normalizing, annealing and brazing.

- Each zone with individual 100% forced convection heating!
- Silicon carbide skid-type hearth fully supports light-weight trays.
- Super-alloyed ceramic tubes guaranteed one year. Ipsen "Flame-Busters" complete combustion within the heating portion of the tube.
- Both forced convection atmosphere cooling and hot-oil quench.
- Ipsen pusher units are shipped completely piped, wired, and tested.

Cross-section diagrams and complete details covering all sizes of Ipsen pusher units are shown in Bulletin P-59. Send for your copy, today.

AUTOMATIC Ipsen HEAT TREATING UNITS

IPSEN INDUSTRIES, INC. • 723 SOUTH MAIN STREET • ROCKFORD, ILLINOIS

Circle 557 on Page 48A

Superex is easily combined with other insulations such as Johns-Manville Thermobestos®, J-M 85% Magnesia or J-M Insulating Fire Brick.

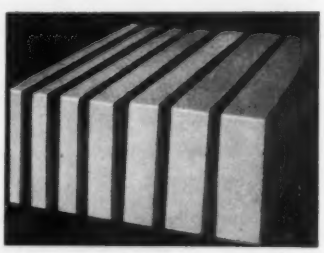
Only Johns-Manville Superex insulation performs 3 ways better at high temperature!

Few industrial products are so outstandingly superior, or so widely used in their area of application, as Johns-Manville Superex® Insulation.

A block insulation formulated of diatomaceous silica and asbestos for furnace and other applications, Johns-Manville Superex brings many advantages to high-temperature service—each contributing to reduced construction, maintenance and operating costs.

Superex is installed with measurable savings in time and labor! It is easy to cut and handle . . . weighs only 2 lbs. per sq. ft. per inch thickness . . . available in a wide variety of large block shapes and sizes. At high temperature—the material's excellent insulating value, thermal stability and resistance to shrinkage keep fuel costs low. Equally important—Superex saves on maintenance, too . . . easily withstands the daily abuse of normal service.

Send for your copy of IN-190A, the 12-page design and technical data brochure. It lists suggested applications—gives complete heat transmission tables and performance data. *Write for it today.* Address Johns-Manville, Box 14, N.Y. 16, N.Y. In Canada, Port Credit, Ont.



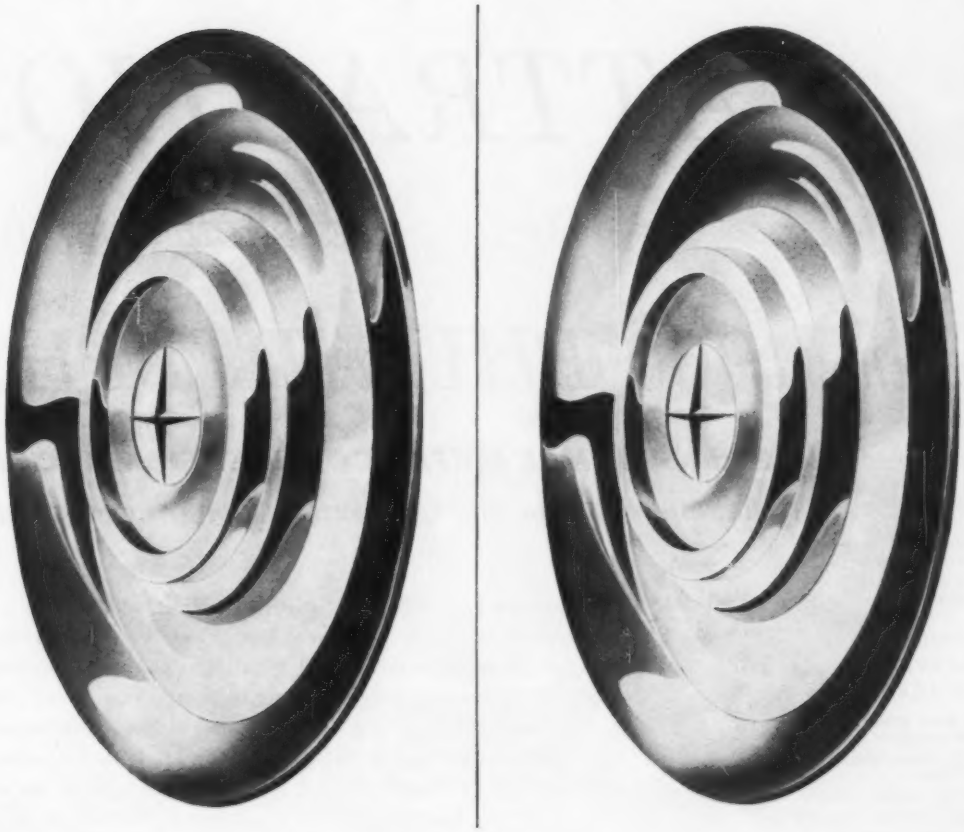
Saves waste. Superex comes in 7 standard thicknesses from 1" to 4". Other sizes available on order.

JOHNS-MANVILLE

JOHNS-MANVILLE JM PRODUCTS

Circle 487 on Page 48A

Which hubcap would you reject?



MCA's RareMeT Compound minimizes surface defects

Deep drawing steels, extensively used in automobile production, are often rejected because of surface defects which, in turn, cause low yields. Only the best quality can withstand deep drawing operations and at the same time give high yields.

Our wide experience in numerous plants throughout the country has proven that small additions of RareMet Compound aid in the manufacture of these steels by increasing hot workability and reducing the size of harmful inclusions.

If increasing demands for better quality, through improved surface, play a part in your operations as a producer, the economical use of MCA RareMet Compound is strongly advised. A letter addressed to the nearest MCA office listed below will bring prompt and confidential response.

MOLYBDENUM

CORPORATION OF AMERICA

2 Gateway Center **Pittsburgh 22, Pa.**

Offices: Pittsburgh, Chicago, Los Angeles, New York, San Francisco
Sales Representatives: Brumley-Donaldson Co., Los Angeles, San Francisco
Subsidiary: Cleveland-Tungsten, Inc., Cleveland
Plants: Washington, Pa., York, Pa.

MCA

Circle 488 on Page 48A

the most DYNAMIC ATTRACTION a show ever had!

at the 1960 PHILADELPHIA

42nd NATIONAL METAL CONGRESS & EXPOSITION

Philadelphia Trade and Convention Center • Oct. 17-21, 1960

EXHIBITORS FROM ELEVEN METALS AREAS

1. Ferrous Metal Producers and Distributors
2. Nonferrous Metal Producers and Distributors
3. Related Engineering Materials
4. Nuclear Materials and Equipment
5. Tool Materials, Cutting-Off and Forming Equipment
6. Industrial Heating Equipment and Supplies
7. Cleaning and Finishing Equipment and Supplies
8. Welding and Joining Equipment and Supplies
9. Testing, Inspection and Control Equipment and Supplies
10. Production and Casting Equipment and Supplies
11. Parts, Forms and Shapes for Design and Applications

Exhibitors at the Philadelphia Metal Show will gather their customers and prospects from the broad metalworking industry, including automotive, aircraft, appliance, ordnance, farm machinery, electrical machinery, instruments, and miscellaneous metalworking manufacturers . . . creating a thriving, effective, profitable marketplace. If your potential for sales lies in any of these areas, the Metal Show should take priority in your sales plan for maximum impact in the Soaring Sixties.

Floor Plan Folders are now available — for complete information, consult the ASM representative nearest to you, or write direct.

NEW YORK — OXford 7-2867
CLEVELAND — JOrdan 4-2271 (Novelty, Ohio)
CHICAGO — WAbash 2-7822

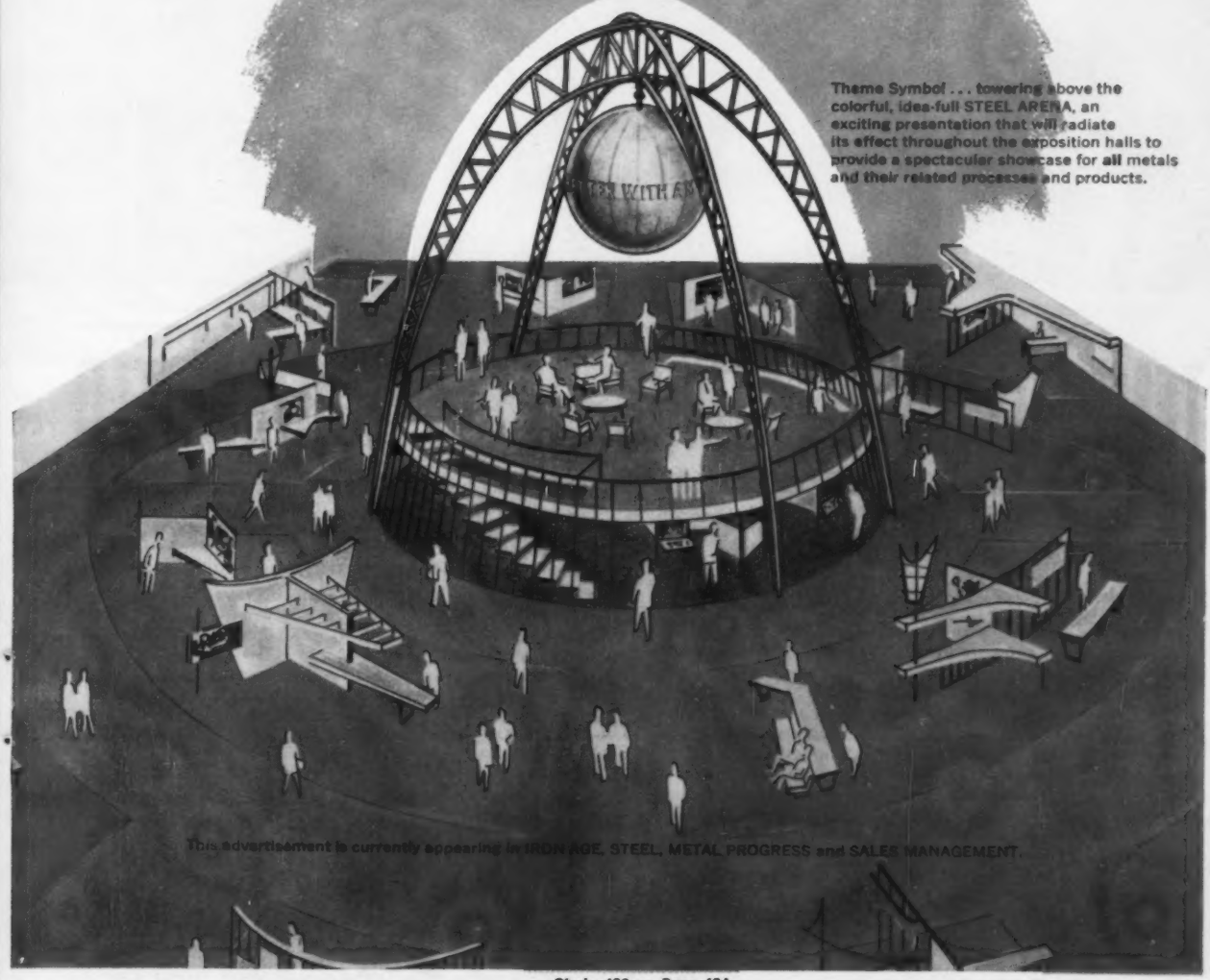
Steel, the sinew that binds the strength of America, will serve as a magnetic attraction to call attention to **every** area of metals technology, ferrous and nonferrous, at the most metallic of all Metal Shows — the 1960 Philadelphia Metal Show, now blue-printed and ready to grow into its full dimensions. This new emphasis on the essential metals of industry reflects a growing specialization . . . a **focusing** of attention . . . to yield a greater benefit. In the evolution of the Metal Show, the time for such refinement has come. Now it is possible to achieve a concentration on **materials** that is unsurpassed anywhere for an intensive person-to-person interchange of information. The STEEL ARENA is the threshold to a whole new world of metals within the exhibits and technical sessions. The pre-eminence of a Metal Show of these dimensions is worth your closest consideration as an exhibitor — you are invited to share its benefit in any of the eleven areas of metals listed.

MAKE PLANS NOW
TO EXHIBIT AT THIS GREATEST OF ALL METAL SHOWS!

AMERICAN SOCIETY FOR METALS
Metals Park • Novelty, Ohio

. . . a benefit to every exhibitor

METAL SHOW

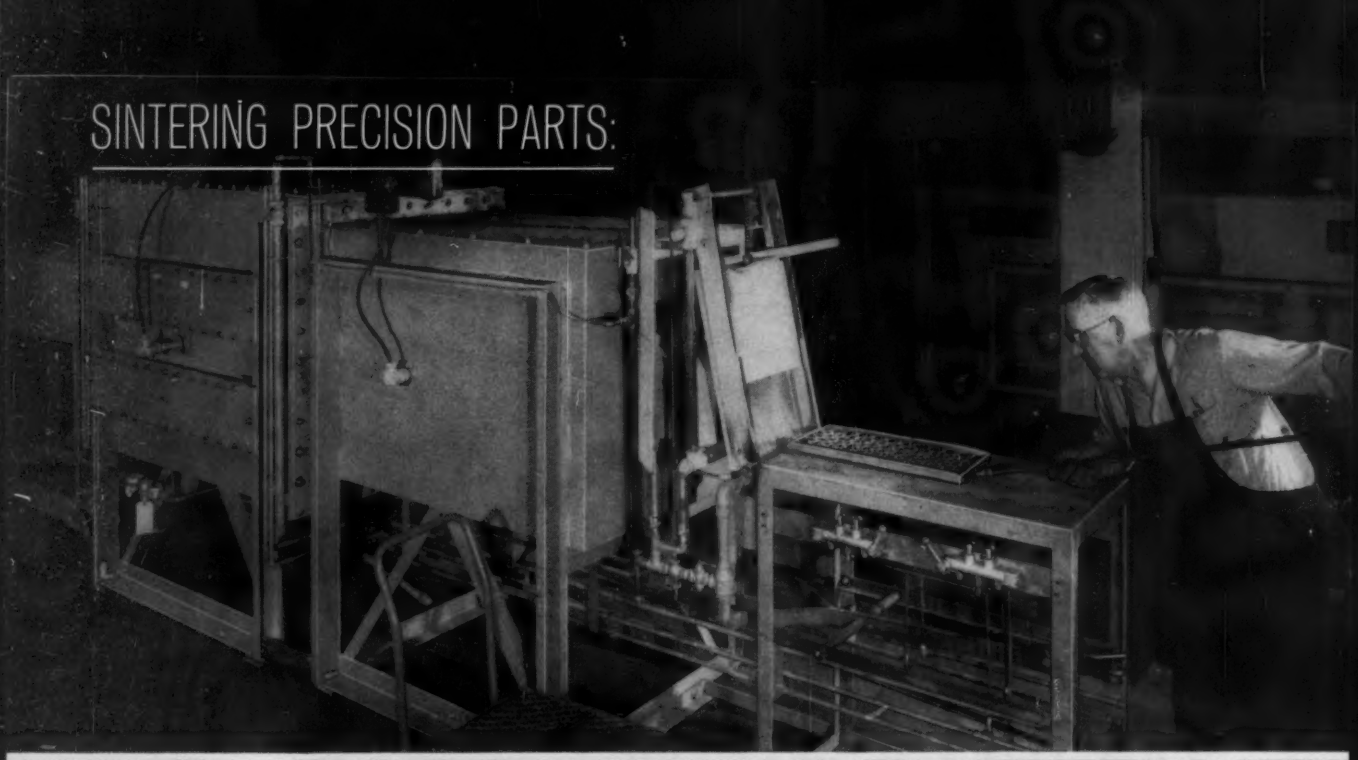


Theme Symbol . . . towering above the colorful, idea-full STEEL ARENA, an exciting presentation that will radiate its effect throughout the exposition halls to provide a spectacular showcase for **all** metals and their related processes and products.

This advertisement is currently appearing in IRON AGE, STEEL, METAL PROGRESS and SALES MANAGEMENT.

Circle 489 on Page 48A

SINTERING PRECISION PARTS:



1. Green compacts are closely grouped on perforated steel trays for maximum productivity.

2. Loaded tray is pushed through gas flame curtain of open charging door into pre-heat chamber.

3. Trayload of sintered parts is drawn from cooling chamber through gas flame curtain of discharge door.

TEMPERATURES, ATMOSPHERES TIGHTLY HELD

Serving a large Eastern metal fabricator, this Harper Box Furnace sinters a variety of precision parts compacted from iron, iron graphite, 4600 series steel and brass powders. As the compacts move through the furnace's pre-heat, high temperature and cooling chambers, both temperature and atmosphere are controlled to insure precision work in numerous ways:

In the pre-heat (or burn-off) chamber, nickel-chromium elements provide temperatures up to 1500° F. An Inconel muffle retains protective atmosphere and prevents volatiles from collecting on the heating elements to cause short circuiting, muffling, grounding or chemical corrosion. Volatiles burned off at the top outlet are discharged through a vent pipe, while carbon and zinc oxide ash are readily brushed from the muffle.

After being pushed into the high temperature chamber, the parts can be processed at temperatures up to 2400° F. With the chamber's pneumatically-operated refractory doors acting as radiation screens, silicon carbide heating elements are arranged above and below the work to maintain the temperature desired within ±5° F throughout 32" of the 36" chamber length. Made of silicon carbide, the hearth plate retains its flatness under high temperatures.

From the high temperature chamber, the parts enter the water-jacketed cooling chamber. Automatic control of water flow assists in regulating work temperature and prevents condensation within the liner during idle periods. From start to finish in this sintering operation, *Harper furnace features insure success.*

When it comes to a sintering or brazing furnace of any type — box, pusher, mesh belt, roller hearth, bell, elevator or pit — you'll find it pays to put it up to Harper — for Harper has the experience to both recommend and build the furnace that's best suited to your needs (with either gas or electricity or both as the source of heat). For more information, write: Harper Electric Furnace Corp., 40 River St., Buffalo 2, N. Y.

HARPER ELECTRIC AND GAS FURNACES

FOR BRAZING, SINTERING, WIRE ANNEALING, BRIGHT ANNEALING, FORGING AND RESEARCH

Circle 490 on Page 48A

12 B&W IFB lined single stack annealing covers in use in the strip annealing department of Weirton Steel Company, a division of National Steel Corporation, at Weirton, West Virginia.

WEIRTON STEEL COMPANY uses lightweight B&W Insulating Firebrick for single stack annealing covers.

These 12 covers, lined with B&W K-20 Insulating Firebrick, have been in service more than two years in the annealing of low and high carbon strip from Weirton's 54″ strip mill. Identical in construction, the covers are over 17 feet from base to skew and over 10 feet in diameter. The domes are of 9″ K-20 IFB construction.

The K-20 is one of B&W's *lightweight* Insulating Firebrick. In fact, B&W K-20 IFB are at least a third of a pound lighter than other 2000 F insulating firebrick. This means savings in the overall weight of portable covers. Additional savings in fuel consumption and cycle time are possible because lightweight B&W IFB store and conduct less heat. Heat is kept in the furnace, not in the lining.

This application points out advantages of light weight in insulating firebrick constructions. And B&W makes the *lightest* weight insulating firebrick. Consult your B&W Refractories Representative for information on how you can profit with lightweight B&W IFB.

Bulletin R-2-H available on request.

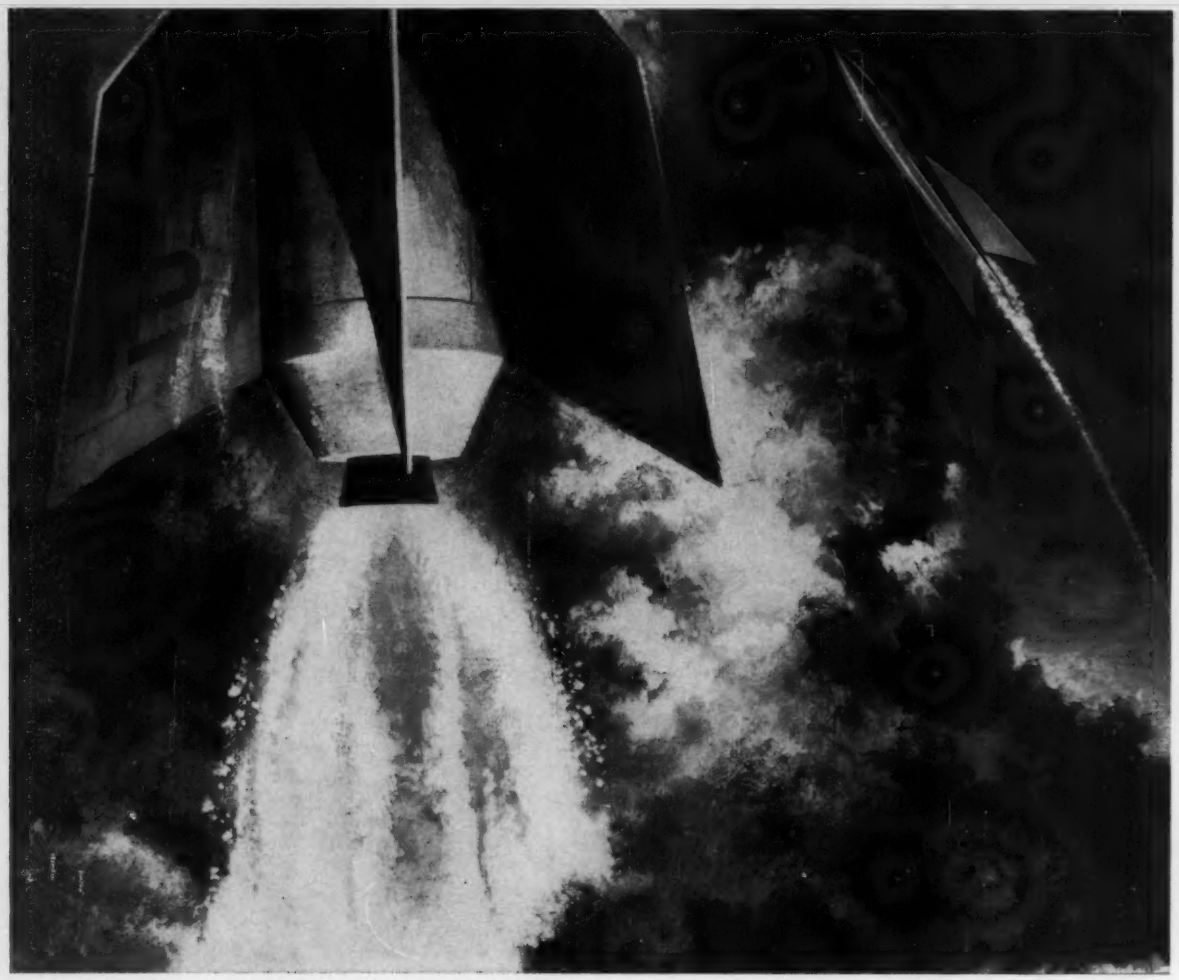
R-617

B&W THE BABCOCK & WILCOX COMPANY

REFRACTORIES DIVISION

B&W Firebrick, Insulating Firebrick, and Refractory Castables, Plastics, Ramming Mixes, Mortars, and Ceramic Fiber.

Circle 493 on Page 48A



SYLVANIA—in the forefront of refractory metals processing

. . . Tungsten and molybdenum ingots up to 10″ diameter, 4 ft. long

. . . Highest purity pellets and powders

Sylvania's latest achievement is the production of refractory metal ingots large enough for direct fabrication into missile and rocket parts. These ingots contain 100% tungsten or molybdenum . . . or they can be supplied as a solid solution alloy of these two elements in many combinations.

Another important Sylvania advance is the in-process machining of these ingots *before* final sintering . . . a distinct cost saving.

However, the smooth as-sintered surface of our standard refractory metal ingots is suitable for many forging and rolling operations.

Pellets and Powders

Sylvania produces highest purity powders and pellets of tungsten and molybdenum and their alloys. Their uniform high quality is the industry standard.

Arc-casting Electrodes

Sylvania's new large-size capabilities offer substantial operating economies for arc-casters. *Electrodes now can be produced in sizes up to 10″ diameter and 4 ft. long.*

• • •

For complete information on these Sylvania refractory metals, write to Sylvania Chemical and Metallurgical Division.

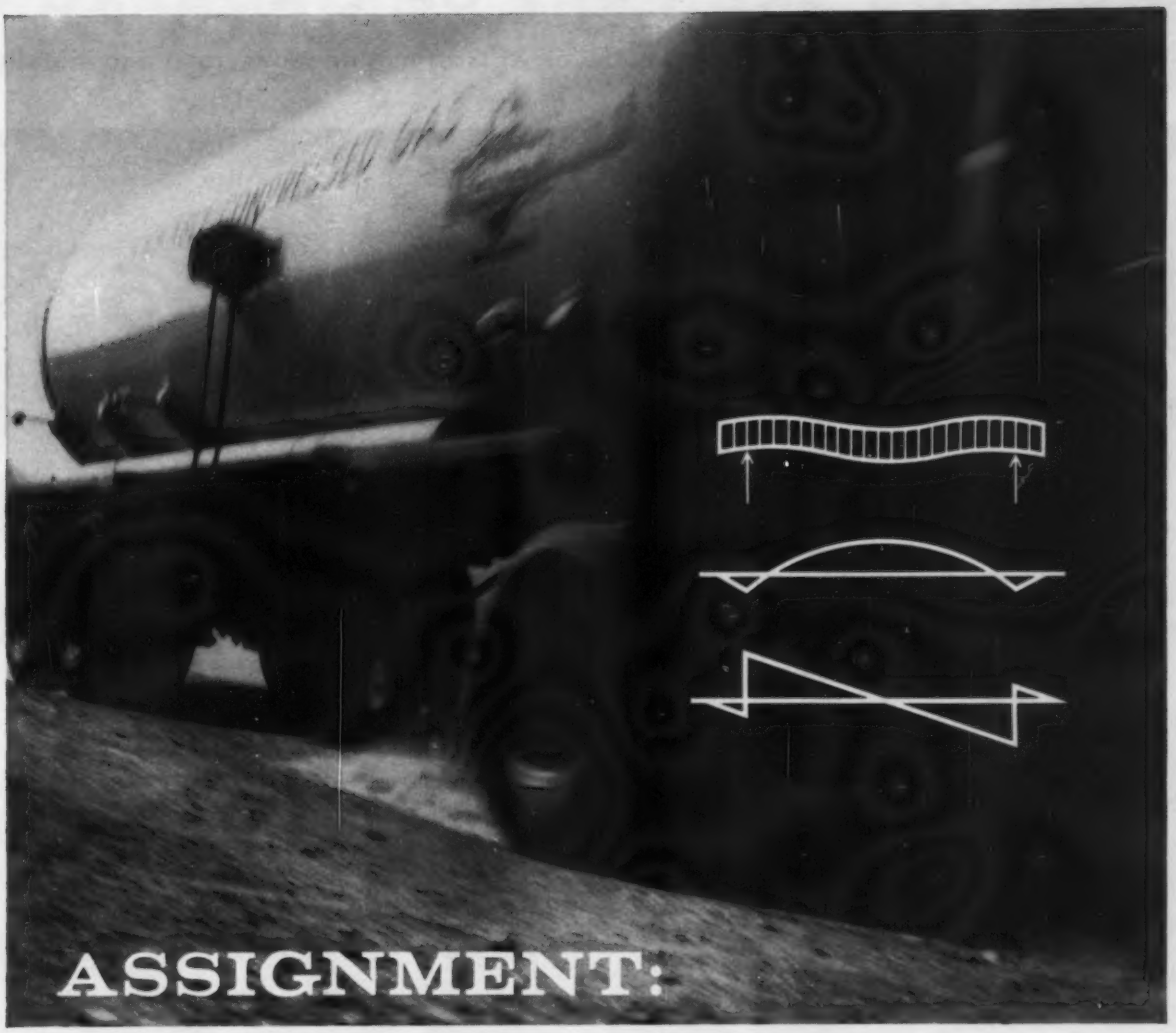
SYLVANIA GENERAL SYSTEM

Subsidiary of

GENERAL TELEPHONE & ELECTRONICS

SYLVANIA ELECTRIC PRODUCTS INC.
Chemical & Metallurgical Div.
Towanda, Penna.

Circle 492 on Page 48A



STRENGTH / WEIGHT

How Lukens *Application Research* can help you find the right steel plate for the job

Designing for maximum payload means taking maximum advantage of today's high strength steels. Experts who know these steels—from a practical as well as technical standpoint—can give invaluable assistance in the early planning stages. This is the job of our Application Engineering staff.

LPG transport tanks and power shovels are widely divergent areas in which Lukens engineers have helped increase payloads.

The use of Lukens "T-1" steel plate and heads in tanks for hauling LP-Gas has fostered an entirely new design concept in the tank truck field. This high tensile, high yield strength steel (100 000 psi) makes it possible to mount wheels *directly on the tank.* The dead weight of heavy underframes goes into payload.

Working with a major producer of power shovels, our staff suggested tough Lukens "T-1" for buckets, dipper sticks, bucket teeth and other key parts. Lightweight, welded steel plate—rather than heavy castings—added as much as 40% to load capacity.

From these successful projects—and many more—our Application Engineers have gained knowledge and experience of value to design engineers. That's why we say... *if your assignment is strength/weight, let it be our assignment, too.* Contact Manager, Application Engineering, F-20 Services Building, Lukens Steel Company, Coatesville, Pa.

Helping Industry Choose Steels That Fit The Job

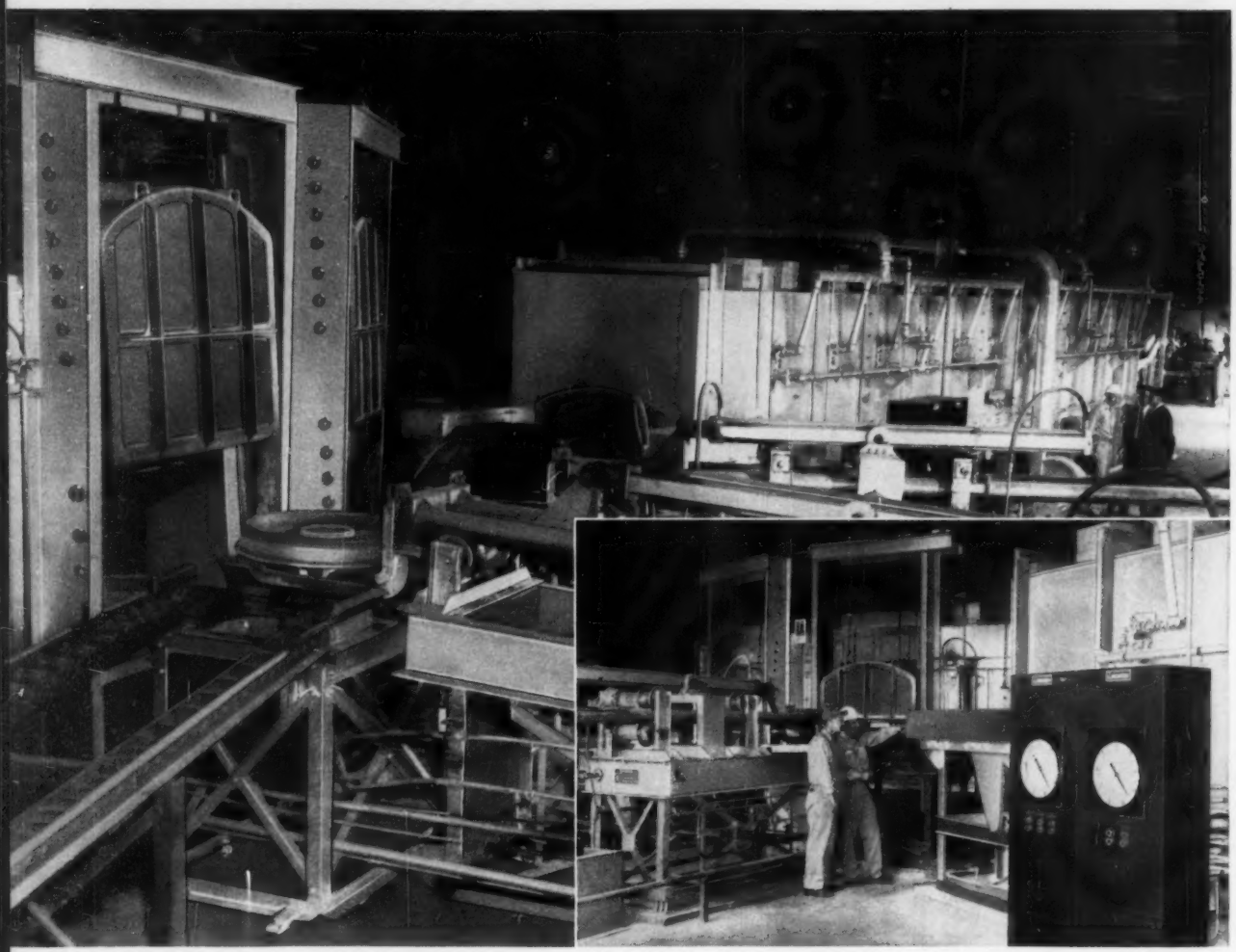
LUKENS

ASK FOR THE LUKENS "T-1" STEEL BULLETIN

Circle 491 on Page 48A

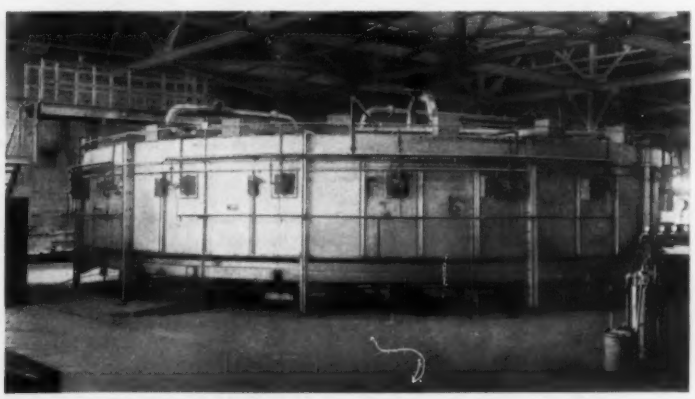
BIG JOBS ARE PART OF LINDBERG'S

Complete, automated heat treating installation at Griffin Wheel designed and installed



Several years ago, Griffin Wheel Company's plant at Colton, California began heat treating car wheels in a Rotary Hearth Furnace designed and installed by Lindberg Industrial Division. It was one of four similar installations at other Griffin plants in United States and Canada. Recently, when production at the Colton plant needed to be doubled, Griffin again called on Lindberg Industrial engineers to develop the necessary methods and equipment. The desired result was accompanied by a specially designed Preheat Furnace shown at the right above, engineered and installed by Lindberg Industrial and automated to work efficiently with the original Rotary Hearth Furnace. Inset shows the Lindberg control panels conveniently installed for operation of both furnaces.

The operation of both furnaces was completely automated. The above photo shows the charging of the Preheat Furnace and the automatic conveyor which moves the wheels through the Preheat Furnace and delivers them to the Rotary Hearth Furnace.



The original Rotary Hearth Furnace at Griffin has an outside diameter of 44'. Initial capacity of 13,000 lbs. per hour was doubled with the installation of the new Preheat Furnace.

FULL SERVICE

by Lindberg Industrial Division

A PLUS DIMENSION IN SERVICE TO USERS OF HEAT FOR INDUSTRY

Most everyone knows Lindberg as a builder of fine equipment for any industrial heating need. But there is a plus dimension to Lindberg's service that is available to any industry whose product requires heat in its making.

For such people we offer the complete designing, engineering, building and installation of the necessary equipment and facilities to process any product requiring heat—in the quality and quantity desired by its maker. This service covers broad requirements—plant layout and construction, when desired, complete, automated production lines or just specially engineered industrial heating equipment efficiently integrated into your production processes.

You obtain many advantages when you offer your industrial heating problems to Lindberg. You get the combined skills of what we believe to be the country's finest group of engineers and technicians in the industrial heating field, with many years experience in the solution of all types of "heat for industry" problems. You need give us only your end product specifications and you will get the installation, from one responsible source, guaranteed to achieve the results you need and ready to go to work at the turn of a switch.

Our experience covers the whole range of industrial heating methods so you can rely on us to recommend the processes most suited for your specific need.

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Lindberg Field Engineers are available in 23 major industrial centers in this United States and Canada (see classified telephone directory) or write direct to: Lindberg Industrial Division, Lindberg Engineering Company, 2321 West Hubbard Street, Chicago 12, Illinois. Los Angeles Plant: 11937 South Regentview Avenue, Downey, California. In Canada: Birlefco-Lindberg, Ltd., Toronto.

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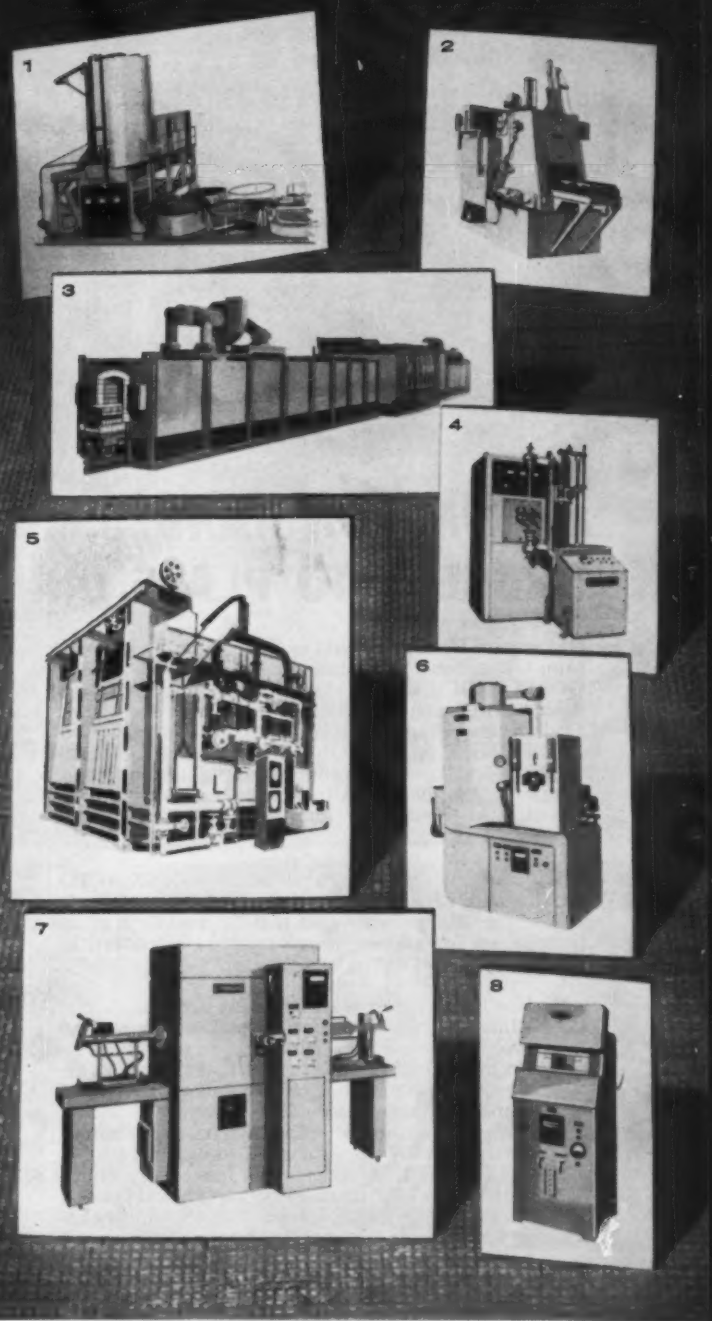

1 Gantry Type Furnaces: Lindberg Industrial Division has installed a number of Gantry Type Furnaces with auxiliary equipment for heat treatment of missile and rocket components.

2 Heat Treating Furnaces: For every requirement, large or small, electric or fuel fired, factory built or field-installed. Shown: Automated Integral Quench Type Carbonitriding Furnace.

3 Ceramic Kilns: All types of kilns: automatic, atmosphere controlled, high temperature, tunnel and periodic. Shown: Tunnel Kiln with two automatic control zones for temperatures up to 3200° F.

4 High Frequency Units: Complete range of induction heating units and furniture. Shown: New Floating Zone Scanner for production of hyperpure materials for semi-conductors.

5 Melting and Holding Furnaces: Equipment for any non-ferrous metal requirement including electric resistance and two chamber induction types, reverberatories, dry hearths and crucibles. Shown: Field-Installed Reverberatory Furnace, 80,000 lb. capacity.

6 Atmosphere Generators: Generators for all required furnace atmospheres. Shown: Hyen Generator for endothermic atmospheres.

7 Pilot Plant Equipment: Complete group of intermediate sized furnaces for pilot plant and small production application. Shown: New Graphite Tube Furnace, temperature range 2500° F. to 5000° F.

8 Laboratory Furnaces: Complete line of laboratory furnaces from simple hot plates to specialized research units. Shown: Versatile, wide temperature range Laboratory Box Furnace.

Circle 516 on Page 48A

One of the fastest computing systems ever developed, the UNIVAC Solid-State Computer performs at internal speeds commonly associated with large-scale equipment. Its remarkable speed and storage capacity enable the UNIVAC Solid-State Computer to eliminate much pre-sorting and pre-collating...and combine calculating, reproducing, gang-punching, data-collation, and tabulating in a single run. Each UNIVAC SSC contains over 1,400 printed circuits plated with AUTRONEX ACID GOLD.

REMINGTON RAND USES AUTRONEX* ACID GOLD PROCESS TO PLATE UNIVAC PRINTED CIRCUITS

Remington Rand, Division of Sperry Rand Corporation, Utica, New York, uses the AUTRONEX ACID GOLD PROCESS to plate printed circuit boards for their world-famous UNIVAC Solid-State Computer Systems and Equipment. Installation of the patented AUTRONEX ACID GOLD PLATING PROCESS for this work, "...totally eliminated resist failures and rejects in the electroplating phase," according to a report from Remington Rand's Supervisor of Chemical Engineering.

This report goes on to say that "AUTRONEX ACID GOLD in printed circuit production offers definite advantages and promotes the highest quality production." Here are some of these advantages proved in Remington Rand's own laboratories:

1. Harder and more wear-resistant surfaces.
2. Elimination of one step in plating cycle — no cyanide gold strike required.
3. Promotes higher bond strength of circuit to dielectric base material by minimizing danger of damaging the adhesive layer.
4. Solder flow through plated holes is definitely better, thereby improving over-all quality.
5. AUTRONEX ACID GOLD has totally eliminated circuit lifting and rejects on boards plated after etching. Formulations used previously attacked the adhesive and undermined the circuit paths.

The conclusion of the report we have been quoting needs no further comment: "We would like to commend the manner in which your company has serviced us in regards to materials, equipment and valuable advice. In many instances your promptness in making equipment and materials delivery has been instrumental in meeting vital production target dates."

The patented AUTRONEX ACID GOLD PLATING PROCESS has production-proved its unique advantages for over two years in the plants of leading manufacturers the world over. AUTRONEX can help *you* make a better, more reliable product—probably at far less cost than with any gold plating formulation you may be presently using. Evaluate AUTRONEX ACID GOLD ELECTROPLATE in your own plant, *on your own product*. We'd be happy to plate sample parts for you at no obligation. Write...wire...or 'phone. We'll make all the arrangements.

*Trademark for Sel-Rex patented Acid Gold Plating Process

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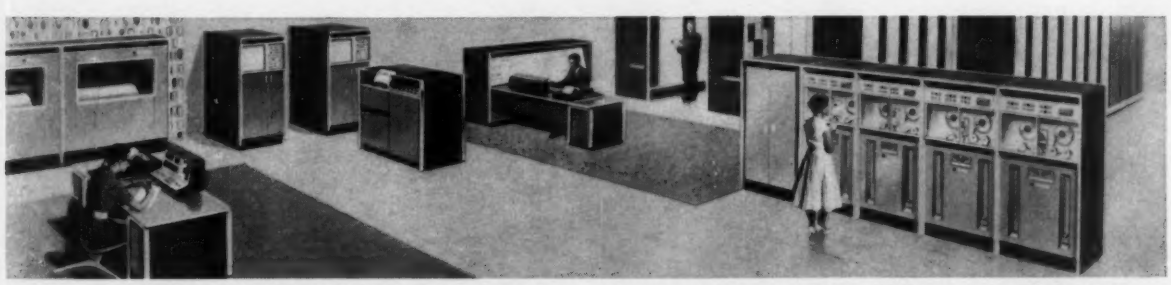


The world's fastest and most advanced electronic data processing system for business and scientific use, the UNIVAC Larc Solid-State computer, by the Remington Rand Division, Sperry Rand Corporation. The new system, which operates up to 200 times faster than any computer in existence, can perform 250,000 additions and subtractions of 12-digit decimal numbers per second.

Circle 494 on Page 48A

PRECISE GAUGE CONTROL

to your restricted specifications with

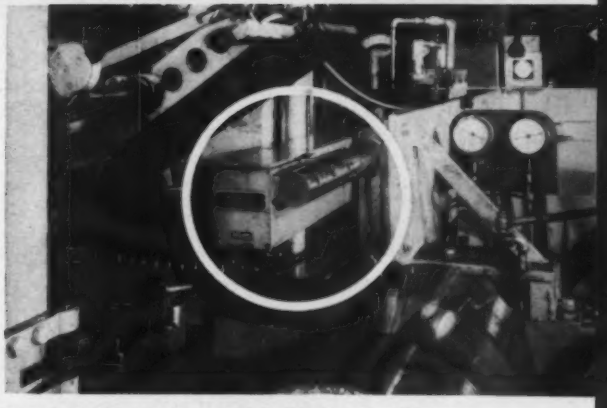
J&L Cold Rolled Strip Steels

In many critical applications, precise gauge control yields worthwhile savings on production costs. Not only does it mean increased tool life but it eliminates grinding for gauge accuracy and reduces quality control costs by minimizing inspection schedules.

At J&L, specially designed cold mills make it possible to exercise precise gauge control — to your specifications. J&L processing techniques include the use of AccuRay gauges to provide exact measurements during rolling. Gauge accuracy is just one of the many restricted specifications which can be met consistently by J&L.

J&L offers you an experienced organization devoted to strip steel processing combined with fully integrated production facilities.

For your convenience, precision strip facilities are available to you in our plants at Youngstown, Indianapolis, Los Angeles and Kenilworth (N. J.)



Typical of J&L precise control is this AccuRay thickness gauge to help assure tolerances on cold rolled strip steels.

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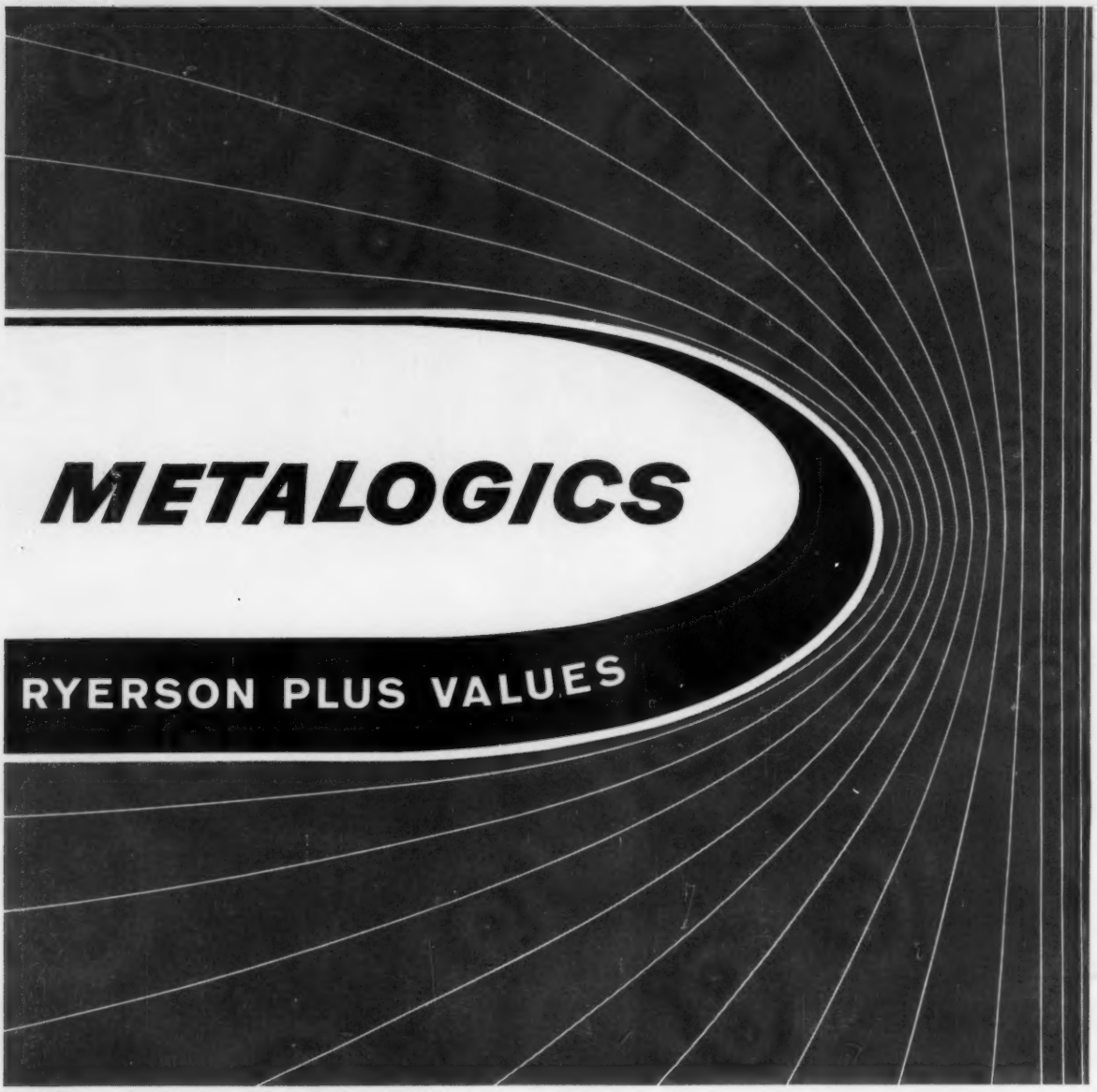
Circle 495 on Page 48A



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Circle 560 on Page 48A

Technical NEWS in Brief

Aluminum Gains in the Automotive Field

Aluminum is on firm ground in the auto industry with use of the metal showing a steady increase during recent years. Since 1956 (when detailed studies were begun by Aluminum Co. of America) the average weight of aluminum per car has risen from 35 lb. to almost 51 lb. last year.

Estimates put the weight of aluminum in 1960 models at an average of 56 lb. per car.

Most notable application this year in in Corvair's aluminum engine, cast in permanent mold of 355-T 6 alloy. The car carries a total of about 103 lb. of aluminum. Examples of functional uses in other compact cars lie in the transmission case and its extension on Ford's Falcon (permanent molded 333 alloy), and the alternator housing for the Valient.

Aluminum has also made significant advances in alloys for decorative trim. Mainstays are the high-purity alloys such as the 5357, 5457, and 5557 series. Low iron and silicon content is required for best bright anodizing. Typical examples are window molding, grilles, decorative side panels.

The industry is looking for the introduction of aluminum bumpers as one of its next major moves into the automotive field. Bumpers, now more decorative than functional, will probably be made of clad aluminum. For strength, the core will be an aluminum-magnesium alloy with outer layers of a high-purity alloy which can be bright anodized. First application of aluminum bumpers may be on the compact cars for which simple bumper cross sections can be extruded. It is claimed that the light bumper would actually be 10 to 15% cheaper than existing bumpers. Delay stems from the change in tooling which would be required. Biggest advantage is corrosion resistance, claimed to be better than plated coatings and not seriously affected even if the bumper is damaged.

The industry is also concentrating heavily on developing die-casting alloys and improved casting techniques. Unfortunately, for decorative parts at least, those alloys which are best for bright anodizing are not very good for die casting. Current problems are swirling and rough surfaces caused by castings sticking to the mold.

Inroads in radiator production are being made without the fanfare of a few years ago. The fuel injection model of Chevrolet's Corvette, for example, now comes with an aluminum radiator. General practice is to clad a thin core of 3 S or 2 S sheet with 7072 alloy (1.5% Zn) on one side and 4043 (5% Si) on the other. The zinc-bearing layer is applied for corrosion protection. Fins and tubes are joined by dip brazing the fixtured parts in a salt bath making use of the silicon-bearing coating. Potential weight savings are on the order of 10 lb. and it is claimed that the aluminum radiator is up to $5 cheaper than its copper and brass counterpart.

Titanium: New Applications and Revived Hope

About 15% of titanium produced in 1959 was directed to civilian applications. Most of this

TITANIUM PARTS RESIST CORROSION

Impellers Have Long Life in Chemical Solutions

went into commercial aircraft. However, by far the largest demand for titanium still stems from builders of military aircraft, but 1959 saw the beginning of a new trend in military use of the metal – some 15% of titanium shipped was destined for missile applications. This is an impressive increase over 1958 when missiles called for less than 1%.

Recent progress in the use of titanium in rockets, cited by T. W. Lippert, Titanium Metals Corp. of America, includes:

- Results of a survey by Pratt & Whitney Aircraft indicate that for motor cases of solid rockets, a titanium alloy is 30% stronger (or lighter) than the best alternate metals.
- The fourth stage of the Juno II which boosted the Pioneer IV into orbit used a titanium rocket case.
- A titanium alloy, originally developed to increase the maximum operating temperature of jet engines, also shows promise as a missile structural alloy.

In commercial aircraft, weight savings mean economic gains. For example, one airline claims that an additional $525 (at mail rates) can be realized on each coast-to-coast flight because titanium employed in the DC-8 increases its payload by 1000 lb.

Not to be overlooked is the role of titanium in the chemical industry where its excellent corrosion resistance is often well worth the premium price. Even in most inorganic salts titanium valves, pipe and pump parts (picture on p. 65) show little corrosion.

Another important potential area of growth is in food processing. Titanium has demonstrated in recent tests that it resists damaging corrosion in solutions which usually attack nickel and stainless steel.

A significant trend is pointed out by H. K. Inteman, president of Union Carbide Metals Co., in his year-end review: Attitude of equipment fabricators toward titanium is changing. It is being looked on now as a normal metal of assembly rather than one which is a problem to work with.

New Steels: High-Nickel System and a Modified Alloy

Two new steel developments – both aimed at applications where strength and weight are important – have been recently announced. Yield strengths of over 290,000 psi. have been reported by International Nickel Co. for a new series of nickel alloy steels. The new alloys, which contain 20 to 30% nickel, achieve high strength by air cooling from the heat treating temperature. Good ductility (6 to 10%) and reduction in area (20%) are reported for yield strengths on the order of 250,000 psi. The best combination of strength and ductility seems to be at a composition of 25% Ni, 2 to 6% of Ti or Al or a combination of the two, 0.05% C (max.), balance Fe.

Typical of the possible applications are pressure vessels, which can be fabricated by welding in the hardened condition without preheat, and bearings which require wear resistance as well as high strength. Although not yet available commercially, the nickel-iron alloys have been produced in limited quantities of bars, plate, sheet and tubing.

• • •

Stronger than 4340 by 7% is the claim made by U.S. Steel Corp. for its new "Strux". The new steel contains 0.40 to 0.47 C, 0.75 to 1.00 Mn, 0.50 to 0.80 Si, 0.60 to 0.90 Ni, 0.80 to 1.05 Cr, and 0.45 to 0.60 Mo. Primarily aimed at the aircraft and missile field, it can be quenched and tempered to tensile strengths in the range of 280,000 to 300,000 psi. Typical longitudinal mechanical properties of a forged round after tempering at 550° F. are 243,000 psi. yield strength (0.2% offset), 281,000 psi. tensile strength, 11% elongation, and 38% reduction in area.

Bendix engineers have used Strux in the landing gear of the A 3 J, the Navy's new attack bomber. Landing loads on each main gear run over 100,000 lb. when this plane hits the flight deck of an aircraft carrier.

Special Paints for Missile Heat

The search for materials and techniques capable of protecting missile nose cones, skins and other temperature-sensitive surfaces has led to the development of a paint-like compound which dissipates heat mainly by sublimation. Called "Thermo-lag", by its developer, Emerson Electric Mfg. Co., the paint can be applied with conventional spraying, brushing and dipping equipment.

NEW APPROACH TO HEAT PROBLEM
Coating Being Baked on Nozzles Protects by Sublimation

Principle behind the paint is that by sublimation it prevents excessive heating. But the combined effects of its specific heat, thermal conductivity, heat shielding ability, and decomposition and ionization of sublimed gases at high temperature

also contribute to its excellent heat-dissipating characteristics. Sublimation temperature and vaporizing time can be tailored by varying the basic formulation and thickness of the coating.

Current uses are mainly in the missiles field. For example, power plant nozzles and resonance suppressors of the "Honest John" missile are coated with paint which sublimes at 2300° F. Tests at 4500° F. (reached in less than 40 millisec.), have also shown that an aluminum suppressor coated with Thermo-lag may well turn out to be a satisfactory substitute for one made of insulated steel.

Cryogenic Gyroscope Has Long Life

A unique type of gyroscope, which operates through low-temperature "superconductivity" phenomena, was announced by General Electric Co. last month. This new device is said to spin for long periods with virtually no wear and no current drain. The rotor which is designed for high speed inside a vacuum, floats in a magnetic field. Thus, mechanical bearings are not needed. Gyroscopes of this type are to be used in missile guidance systems.

High-Strength Pipe Solves Thermal Stress Problem

As examples of the unusual working conditions which can be met by properly selected and heat treated steel, consider Freeport Sulphur Co.'s pipe line for transporting sulphur from off-shore wells to storage tanks at Grand Isle, La. Three pipes are concentric. The inmost one, 6 in. O.D., carries the molten sulphur at 300° F. Surrounding this is a 7-in. I.D. pipe, the annular space between them carrying live steam. The outer shell (of ordinary pipe) is 14 in. O.D. and it encloses insulation. The whole is buried 5 ft. deep in the ocean floor. The length of the pipeline is 6½ miles. A little computation will indicate that the two inner lines, when brought to working temperature, will be 55 ft. longer than the outer casing!

Rather than take care of this expansion by U-bends, kinks, or slip joints, the engineers decided to use steel of high enough strength to withstand the thermally imposed loads. The two inner pipes (seamless tubes) were made of Jones & Laughlin's "Jalloy No. 1", a 0.15 C, 1.25 Mn, 0.15 Mo tank armor steel which has been used in many structures and mechanical parts but never before in seamless, heat treated tubing. Welded end to end, the outer 14-in. casing was placed in 10,000 psi. tension by a 135-ton pull and both ends anchored securely. The inner lines were then heated to 225° F., allowed to expand freely (about 35 ft.) and while hot their two ends fixed to the outer casing.

Thus during operation (sulphur at 300° F., casing at 50° F.), the stresses in the hot pipe will be compressive. If the sulphur is drained and the line goes cold, the thermal stress reverses and becomes about 45,000 psi. in tension. Hence the choice of heat treated alloy steel with yield of about 60,000 psi.

PIPELINE FOR MOVING HOT SULPHUR
Inner Lines Are Made of High-Strength Steel to Withstand Thermal Stresses

Beryllium Fasteners Offer Special Properties

Beryllium has taken on new singificance as a fastener material. First applications have been in missiles and space vehicles but beryllium bolts and other threaded parts will probably find early use in atomic equipment. Its weight is only 25% that of ferrous alloys, 70% that of aluminum and half that of titanium. Potentially, one pound of beryllium will do the job of two pounds of steel. Beryllium also has significant nuclear properties.

BERYLLIUM BOLTS GROUND FOR CLOSE FIT
Threads Are Cold Formed

Beryllium fasteners are already being used to a limited but growing extent. No serious fabrication problems have arisen at Standard Pressed Steel Co's new Exotic Metals Lab. where development

and evaluation work is being carried out under Air Force sponsorship. Notch sensitivity is still a major problem which prevents full realization of the metal's potential. In missile guidance systems, one of the most immediate applications, beryllium fasteners are being used where shear loads must be carried. Notch sensitivity is not as critical under shear as it is when tensile loads are applied. Threads are kept away from stressed areas.

Materials Progress in Nonmetallics for Bearings

The selection of nonmetallics or plastics for bearing applications requires the same approach as applies to metals. Just as no one metal or composite will suffice for all jobs, no one plastic or composite is satisfactory for all dry bearing applications. Each use needs to be separately engineered. This point was made by R. E. Harmon, U. S. Gasket Co., in discussing progress in plastics for bearing applications at the S.A.E. annual meeting in Detroit. Developments in nonmetallic bearing materials brought out by Mr. Harmon which are of interest to metals engineers follow.

The most stable of all plastics is the fluorinated version of polyethylene – polytetrafluoroethylene, more commonly known as "Teflon" TFE fluorocarbon resin. This material combines high-temperature resistance with a low coefficient of friction and is the outstanding candidate among the plastics, when properly reinforced or treated, for greaseless bearings in automotive and other general applications as given below: (*a*) where contamination is critical; (*b*) with nonlubricating liquids; (*c*) with corrosive substances; (*d*) at low temperature (−320° F.); (*e*) at elevated temperature (500° F.); (*f*) at high humidity; (*g*) where stickup is critical.

Also considered as bearing-type plastics are nylon, "Teflon" FEP fluorocarbon resin and "Delrin" acetal resin. The latter two classes are in the development production stage.

Plastic dry bearings fall into the following types: (*a*) unmodified or natural state types, (*b*) filled mixtures, (*c*) compositions impregnated into wire screen or perforated metal with or without attached metal backing, (*d*) woven fabric usually bonded by adhesives to metal or other plastic backings, (*e*) impregnated porous bronze with metal backing. The newer types are the latter three.

Fillers greatly improve the physical properties important in a bearing. Glass fibers mixed with fluorocarbon resins (TFE resin) and nylon were first employed. While glass is still employed, asbestos, molybdenum disulphide, carbon, bronze and iron oxide are used alone or in combination for various applications. These fillers in TFE increase load-carrying capacity, improve wear resistance (up to 500%) and raise the top temperature limit. Filled plastic bearings are characterized by a constant wear curve. Examples of their use are in power steering units, farm equipment and railroad passenger car applications.

Metal-reinforced plastic bearings will carry greater loads than natural state or filled mixtures. The metal becomes the load-bearing member with the plastic acting as the wear resisting surface. Most of these types use TFE resin as the wear surface although nylon-clad metal is available.

One of the best performing unlubricated bearings is a composite consisting of a steel backing strip, a middle layer of porous bronze filled with a mixture of TFE resin and lead powder and an overlay of 0.001 in. of the TFE-lead mixture. This composite overcomes many of the limiting factors for natural state plastics and provides the lowest thermal expansion and best heat conductivity of any dry bearing. It is used for high-velocity service (up to 8000 rpm.) in automotive applications. This composite will also run cooler than other dry bearings and wear rate is very low, a typical value being 4×10^{-7} in. per year.

From Here and There . . .

Midvale-Heppenstall Co. of Philadelphia has announced it will install a consumable-electrode vacuum melting furnace capable of producing ingots 40 in. in diameter, weighing 25 tons. Most of the output (8000 tons annually) will be directed to the company's facilities for die blocks, steel rolls, turbine shafts and other parts requiring vacuum-melted metal.

• • •

"The chromium-nickel-manganese stainless steels, generally called the 200-series steels are a fast growing sector within the growing stainless steel market," according to H. K. Intemann, president of Union Carbide Metals Co. He predicts a 25% increase in production of this series – important in architectural and appliance applications – for 1960 compared with last year.

• • •

In announcing a new screw machine stock alloy X 6262, Alcoa states that it offers better machinability, and greater strength than 6061 with corrosion resistance and finishing properties comparable to that alloy.

More About Malleable Iron at Elevated Temperatures

Our old friends the malleable irons have some interesting elevated-temperature properties, such as excellent creep resistance and strength. In pistons for diesel engines and in furnace fixtures, where reliability and long life are required, for example, they have been doing a good job for years. For design engineers and metallurgists alike, more specific information on the performance of malleable irons at elevated temperatures is coming next month, when *Metal Progress* will present a comprehensive report of recent work carried out under direction of the Malleable Founders' Society.

Metal Progress
Vol. 77, No. 2 February 1960

Hydroforging... a New Fabricating Technique for Tubing

*By M. L. SAMUELS**

In centrifugally cast tubes of austenitic stainless steel, the coarse columnar structure can be broken up by a drastic hydraulic expansion from the inside. Annealing at 1950 to 2050° F. recrystallizes the cold worked metal (to form small equiaxed grains) and removes all residual stresses. Yield and tensile strengths rise 16 to 20% without loss in ductility. (G14b; SS, 4-60)

FOR SOME YEARS, piping for special applications has been of austenitic stainless steels centrifugally cast in metal molds. This product, having performed satisfactorily at elevated temperatures and in corrosive environments, has been accepted everywhere.

There has been one problem, however. As cast, these pipes have a coarsely crystalline columnar structure, though their mechanical and chemical properties meet all requirements for cast piping. Since not many metallurgists have had first-hand experience with such structures, questions regarding their suitability have been raised at times. Furthermore, ultrasonic testing is not feasible, and mechanical properties are somewhat below those obtained with a wrought fine-grained austenitic steel of the same analysis.

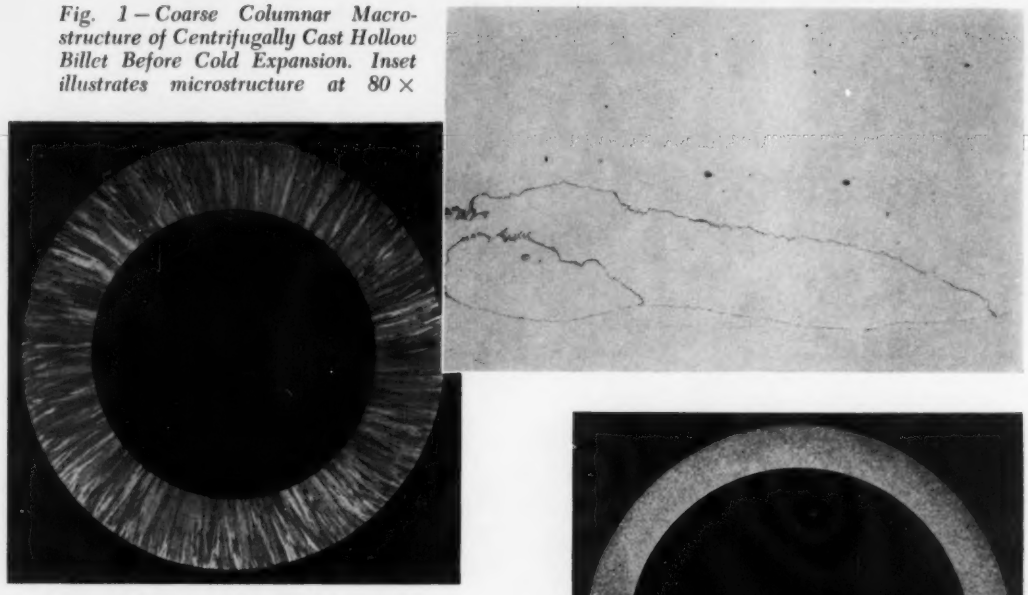
For these reasons, we have given much thought to methods for refining the grain of the cast structure. The objectives were to preserve the advantages of casting a hollow cylinder, and at the same time produce a material equivalent to a wrought product in grain size and strength. After much work, we devised a process which achieves these aims. For grain refinement, we expand the casting while cold and then anneal it for recrystallization. This process we call "hydroforging"; its development is described in this article.

Exploratory Work

Test data accumulated over several years have shown that austenitic grades centrifugally cast in metal molds have high ductility. For example, Type 304 castings have an average elongation of about 60% and reduction in area of about 70%. This suggested that such tubu-

*Research Metallurgist, U. S. Pipe and Foundry Co., Burlington, N.J.

Fig. 1 – Coarse Columnar Macrostructure of Centrifugally Cast Hollow Billet Before Cold Expansion. Inset illustrates microstructure at 80 ×



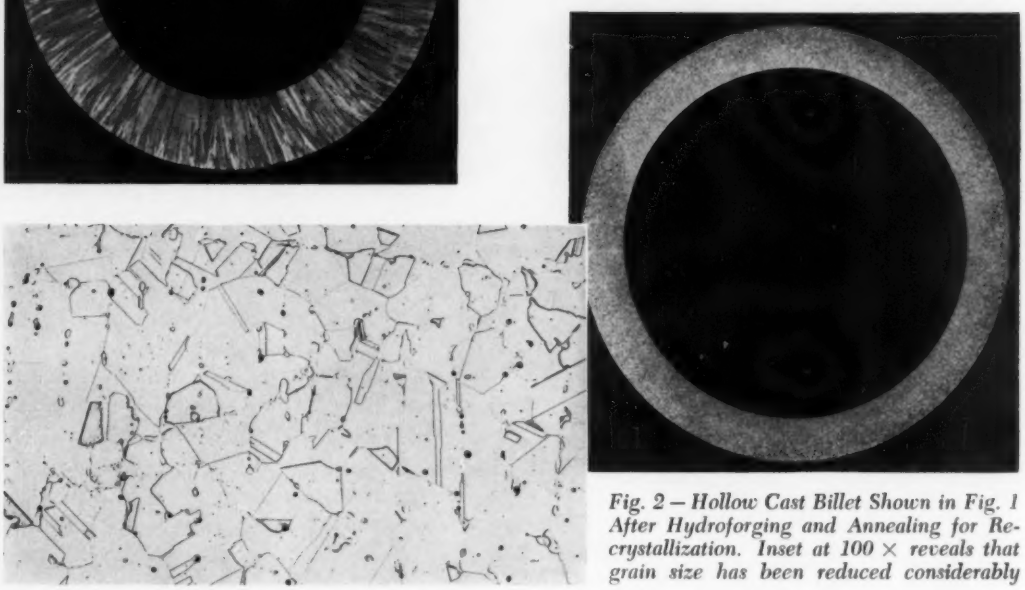


Fig. 2 – Hollow Cast Billet Shown in Fig. 1 After Hydroforging and Annealing for Recrystallization. Inset at 100 × reveals that grain size has been reduced considerably

lar castings might undergo, without rupturing, a cold expansion drastic enough so that subsequent annealing would produce recrystallization and grain refinement. To check this supposition, we started with a casting which exhibited a coarsely columnar grain such as shown in Fig. 1. There were two initial questions: "How much cold expansion would be needed for complete recrystallization during a subsequent anneal?", and "Would the casting be able to withstand the required expansion without rupturing?"

To answer the first question, two schemes for tensile testing were explored. In one method, conical tensile specimens were machined from the wall of a centrifugal casting and marked as shown in Fig. 3. After testing to failure, the specimen was annealed (water quenched from 1950° F.), split longitudinally, and macroetched. As Fig. 3 shows, the sharp transition between the recrystallized and unaffected grains allows an estimation of the breaking load at the transition cross section. This same load-per-unit-area was then applied to a standard 0.505-in. diameter tensile specimen to obtain the corresponding elongation. This value would then be roughly equivalent to the percent increase in the mean diameter required for the outside diameter of a casting.

The other method was more laborious but more revealing. A series of 26 oversize tensile specimens was prepared from a casting. Each successive specimen was elongated in steps of 2% over a span from 0 to 52%, as shown in Fig. 4. Each stretched specimen was then given a recrystallizing anneal, remachined to a standard

size, and broken in tension. Figure 5 illustrates the results graphically.

The shape of the curve is quite significant. At first, strength increased mildly; then, between 6 and 12%, the rise in strength was very rapid. Most significant, however, is the flattening of the strength curve above 20%. The grain was completely refined at 20%, accounting for the large increase in strength. Further stretching merely resulted in a slightly finer grain size.

How the Data Were Applied

This information indicated that uniform grain refinement could be achieved by expansion. Since the smallest expansion would occur at the outside diameter, we aimed at an increase of 20% in the outside circumference. The rest of the wall section would then expand more than 20%, and be assured of grain refinement. As the curve was relatively flat for extensions above this level, a good wall-to-wall uniformity of grain size and strength was promised.

Next, would a casting actually take this amount of stretch without rupturing during the expansion process? After all, it is one thing to test specimens and another to subject an entire casting to free expansion. This is particularly true when the expansion at the inside diameter will be considerably greater than the minimum expansion required for grain refinement at the outside diameter.

Early expansions were limited to relatively

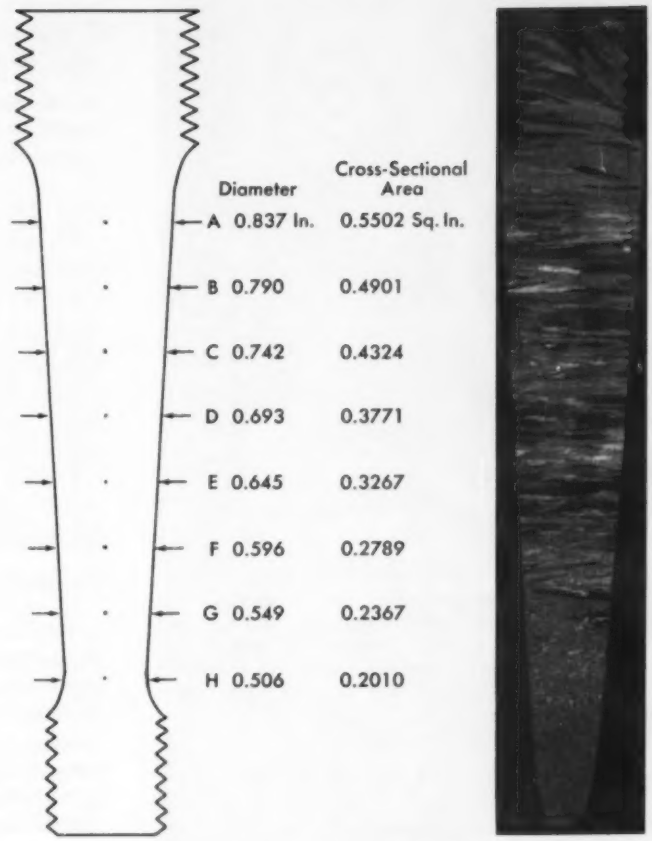
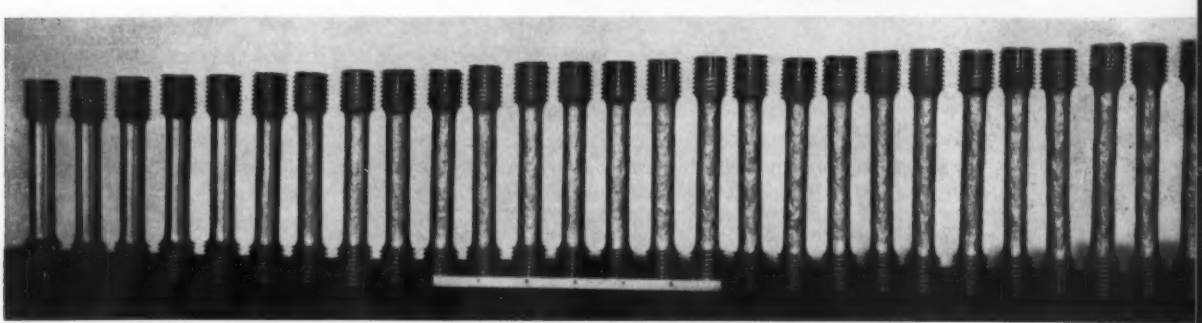


Fig. 3 — Tapered Tensile Bar for Demonstrating Recrystallization. Photo shows conical test specimen after breaking and annealing (actual size). The taper provides varying degrees of cold deformation — maximum at the small end, and gradually decreasing with increasing cross-sectional area. Drawing shows actual dimensions of test specimen

Fig. 4 — Oversize Tensile Bars Cut From a Cast Ring Coupon, and Elongated in 2% Steps to 52%. After lengthening, the bars were annealed, machined to the standard 0.357-in. diameter, and tested. Results are graphically shown in Fig. 5



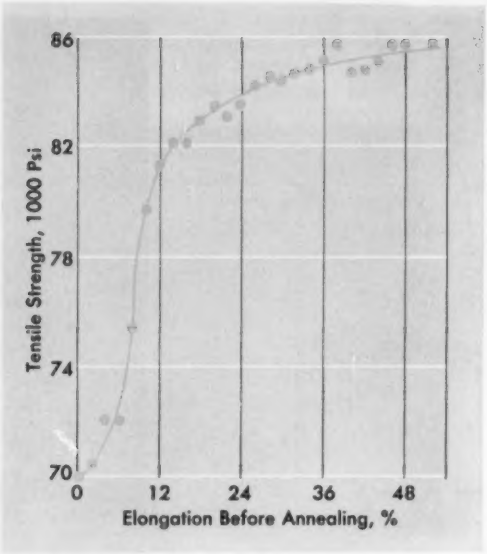


Fig. 5 — Graph of Results From Tests Shown in Fig. 4. At first, the rise in strength is slight; then, as recrystallization begins, the strength rises rapidly. Between 16 and 20%, recrystallization is complete, and the strength again rises slowly. The steel is Type 316

short castings, ranging in diameter from 8 to 12 in. with wall thicknesses up to 2 in. These early castings were expanded in the free state; that is, no jacket confined the outside diameter to size the tube. Despite this, most of the castings expanded fairly uniformly. Apparently, the first areas to expand developed increased resistance to further expansion; this allowed neighboring sections to catch up.

We found it advisable to have the casting as ductile as possible before expansion. This state was achieved by a solution quench. In this condition, Types 304 and 316 steels regularly withstood a one-step expansion of around 40% on the inside diameter, thereby providing a wide working range. In an outside diameter range of 8 through 48 in., the permissible range of wall thickness for a 40% expansion of the inside diameter and a one-step expansion is:

Outside Diameter	Maximum Wall Thickness for 40% I.D. Expansion
8 in.	1.30 in.
10	1.60
12	1.90
14	2.25
20	3.25
30	4.85
48	7.90

Because of these studies, a tentative process specification was set up calling for a minimum outside diameter expansion of 20% and a maximum inside diameter expansion of 40% in one step. When diameters and wall thicknesses are not within these limits, cold expansion is done in two steps with tubes being annealed after the first expansion.

Drastic Cold Expansion

After considering several possible ways for expanding the cast cylinders, we decided to cap the ends and apply hydraulic pressure internally. This method was tried on successively larger billet sizes with hydraulic pressures ranging from 20,000 to 50,000 psi., depending on wall thickness and cylinder diameter.

Cold expansion is done inside a die or container. As Fig. 6 shows, this is a massive split-clamp structure into which the casting is placed. The inside diameter of the container is that desired for the expanded outside diameter plus machining allowance. It prevents any part of the expanding cylinder from going beyond the desired outside diameter and insures that all parts come up to size full length and are true-round and straight.

Macrostructures and microstructures typical of the "before" and "after" stages are shown in Fig. 1 and 2. As can be seen, hydroforging changes the microstructure considerably. Note,

Table I — How Hydroforging Improves Properties*

Type	Yield Strength	Tensile Strength	Elongation	Reduction in Area
304†	30,660 *(35,900)* psi.	68,550 *(83,200)* psi.	62.8 *(65.8)*%	73.9 *(73.6)*%
316†	32,600 *(38,000)*	68,800 *(81,200)*	52.2 *(57.0)*	66.0 *(67.9)*

*Figures in parentheses and italics represent average properties after hydroforging (cold expansion and anneal).

†For averages: Type 304, 17 samples from 8 heats; Type 316, 15 samples from 7 heats.

for instance, that only portions of the coarse, columnar grains of the casting can be shown. The actual grain size is best visualized from the macrostructure. Conversely, the grain size of the hydroforged tube structure is well defined at 100 diameters; it can be compared directly with the standard A.S.T.M. chart.

A number of direct comparisons have been made between room-temperature tensile properties of individual heats before and after hydroforging. Test results of this sort, from eight heats of A.I.S.I. Type 304 and seven heats from Type 316 stainless, are shown in Table I. This table reveals that grain refinement, from hydroforging, has increased both yield and ultimate strengths up to 20% without loss in ductility. In fact, there is usually a moderate increase in elongation and reduction in area.

It should be noted that the "before" and "after" comparisons shown in Table I are in each instance from the same parent heat. Thus, no effect of compositional variables has entered the picture. Hydroforged materials easily pass the yield and ultimate strength requirements (30,000 and 75,000 psi., respectively) prevailing in wrought austenitic tubing and pipe specifications. Also, mechanical and corrosion properties are virtually isotropic. Comprehensive tests at elevated temperatures also proved that properties of hydroforged castings were equivalent to those for wrought stainless of corresponding grades.

Since most early applications for hydroforgings involved temperatures of about 700° F. and pressures around 2500 psi., creep characteristics were not significant. However, data concerning short-time tensile properties from room temperature to 800° F. were collected.

It should also be possible to use hydroforged pipe at still higher temperatures. We have thus begun long-term programs of stress-rupture and creep testing. To date, results indicate the values expected of a wrought product.

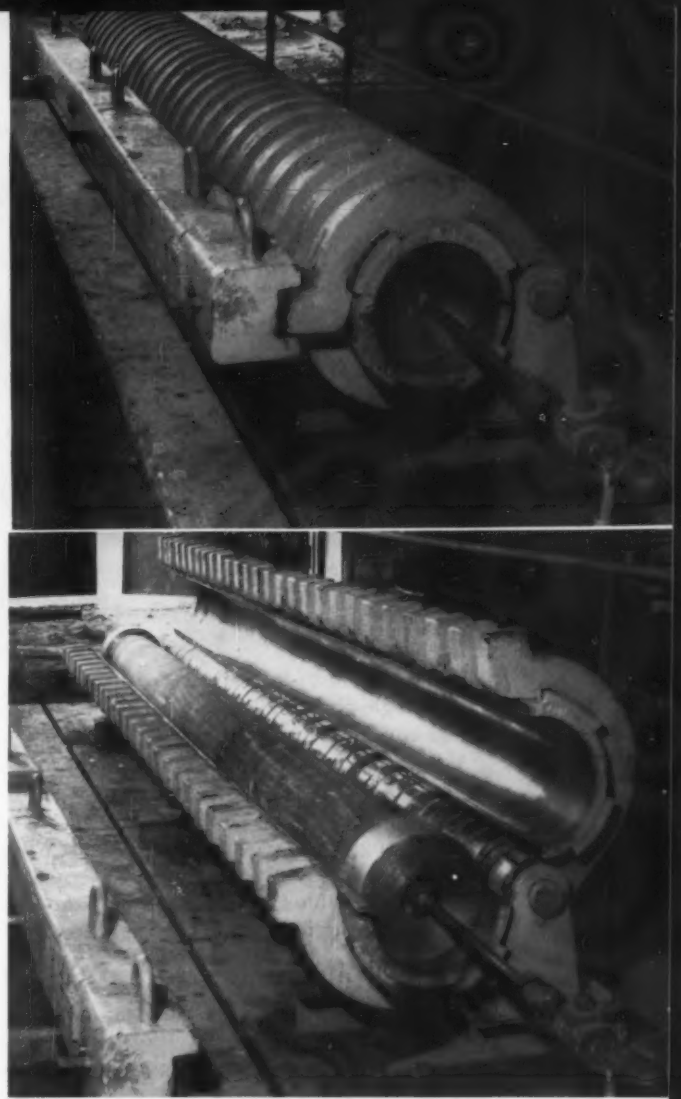


Fig. 6 – View of 18-In. Diameter Die With Hydroforged Cylinder. Open and closed positions are shown

Advantages of Hydroforging

Avoidance of the ingot stage and associated forming into long tubes is the major advantage. The molten metal instead is centrifugally cast into tubular form to the diameters and lengths required. Only cold expanding plus an anneal and machining is then needed. The drastic cold expansion, while done for a different reason, constitutes a rigorous and searching hydrostatic test. All hydroforged cylinders demonstrate immediately that they were able to withstand a bulge of at least 20% without rupture. Subsequent recrystallizing at 1950 to 2050° F. then removes work hardening and stresses introduced by cold working. Carbides are also dissolved.

Another advantage of practical significance: Seamless piping can be produced with a wide range of ferrite content. Some users of stainless piping at either room or moderately elevated temperature prefer the higher strength exhibited by the two-phase or ferrite-containing alloys. This material, however, is not amenable to certain hot working operations such as piercing or extending to form the steamless product. Conversely, hydroforgings can range

Table II – Relationship Between Properties and Structure*

Heat No.†	Yield Strength	Tensile Strength	Elongation	Reduction in Area
R-5568	29,050 *(36,500)* psi.	62,500 *(79,800)* psi.	58.7 *(56.7)*%	72.7 *(72.0)*%
R-5571	29,520 *(32,200)*	64,120 *(80,250)*	52.5 *(56.7)*	67.8 *(67.9)*
R-5570	36,370 *(40,550)*	73,620 *(85,450)*	60.0 *(56.8)*	69.7 *(70.2)*

*Values in parentheses and italics are obtained on hydroforged material.

†Type 316 stainless. R-5568, fully austenitic; R-5571, close to dividing line; R-5570, unbalanced on ferrite side of A.I.S.I. composition range.

from the fully austenitic (or completely single-phase structure) to at least a 10% ferrite content.

Test results from three heats of Type 316 stainless hydroforgings illustrate this latitude in analysis and relationships between properties and composition. One heat (R-5570) was made to the unbalanced or ferrite side of the A.I.S.I. range, another (R-5571) close to the dividing line, and the third (R-5568) on the fully austenitic or single-phase side. Table II lists results before and after hydroforging.

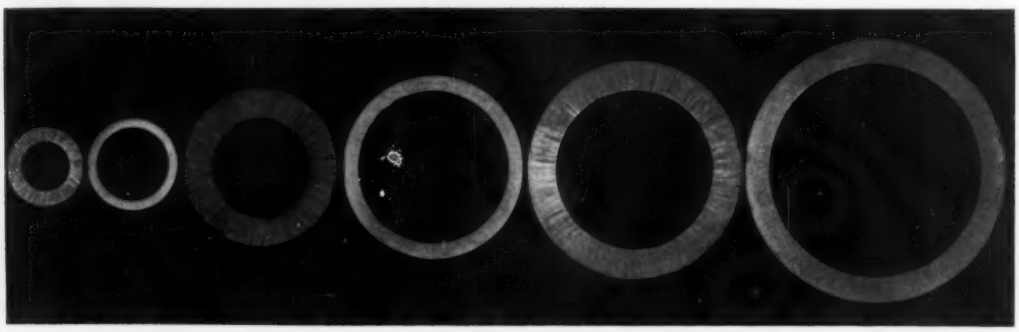
A fairly wide range in diameters of hydroforged pipe has been commercially produced. For example, Fig. 7 shows a series of such hydroforgings. Since centrifugal castings with an outside diameter of 40 to 50 in. can be made, it seems reasonable to expect that they can also be expanded to produce hydroforgings for very large piping or for pressure vessels if such a demand develops. Wall thickness can be increased correspondingly in these larger sizes. With respect to length, hydroforged pipe has been made up to 16 ft. to date, but facilities now available will permit production of pipe more than 20 ft. in length.

Obtainable grain sizes are not quite as fine as can be produced in very small-diameter, thin-walled tubing, which is normally finished by being severely cold worked and annealed. However, grains are usually smaller and more uniform than they are in certain large, heavy-walled forgings which have to be finished at forging temperatures. To date, grain sizes have ranged from 2 to 5 on the A.S.T.M. standard chart, and have always been fine enough to permit ultrasonic testing. This inspection tool, in contrast to localized tests such as tensile or ring flattening, searches every inch of the cylinder. If unrefined remnants of the coarse cast structure existed, the autographic tape record would show their presence.

Conclusion

The hydroforging development has passed through the experimental and pilot production stages, and is now in regular commercial production. Several thousand feet of pipe have been supplied in sizes ranging from 8 through 18 in. in diameter with varying wall thicknesses. Most of this material has been produced for use as primary coolant pipe in the Navy's Nuclear Reactor Program. All the requirements of A.S.T.M. A-376 and 312, including those listed as supplementary, have consistently been met without difficulty in the course of making several hundred commercial heats.

Fig. 7 – "Before" and "After" Macrostructures for a Variety of Sizes. These tubes range from 8⅝ to 25 in. outside diameter and from about 0.906 to over 2 in. in wall thickness



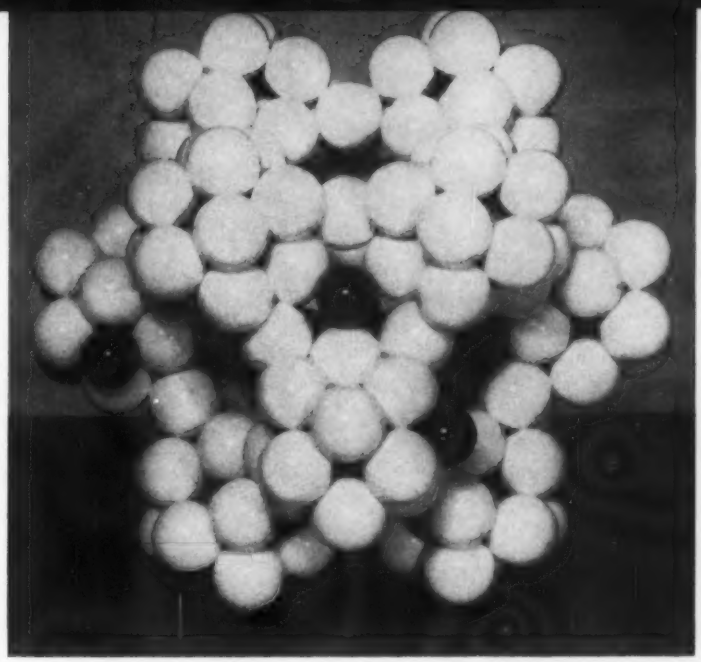


Fig. 1 – Model of a Single Crystal of a Molecular Sieve. White marbles represent oxygen molecules in silicon and aluminum tetroxide tetrahedra, while dark marbles represent the sodium cations in the Type 4 A Molecular Sieve. When the water of hydration is driven from these man-made crystals by heating, a porous structure remains. This structure acts as a strainer to remove unwanted gases

Molecular Sieves in Atmosphere Control

*By HERBERT W. WESTEREN**

These synthetic crystalline compounds, now being widely used in atmosphere generators, have a great affinity for water and other polar compounds, and can separate gases and liquids with remarkable selectivity according to their molecular sizes, polarity and carbon bond saturation. Specific applications in gas drying, air drying, and gas separation are discussed along with the equipment which employs this new adsorptive agent. (J2k, W28a; NM-a)

THE RECENT DEVELOPMENT of a new adsorptive agent, the Molecular Sieve, by the Linde Co. (a division of Union Carbide Corp.) has had a far-reaching effect on the metal industry. A very versatile material, this new product dries gases, air, hydrogen, and chemical streams with great effectiveness. Molecular Sieves have also been found useful in purifying gases and separating hydro-carbons.

The sieve material is produced in three types termed 4 A, 5 A, and 13 X, and can be obtained in cylinders (1/16 or ⅛ in. in diameter by 3 to 5 diameters in length) or in beads. In physical appearance, Molecular Sieves are a chalk-like substance resembling many natural clays, but here the similarity to ordinary materials ends. Molecular Sieves are composed of man-made crystals with properties similar to some natural zeolites. If it were possible to inspect a single crystal, the observer would find that

*Assistant Director of Research, C. I. Hayes, Inc., Cranston, R.I.

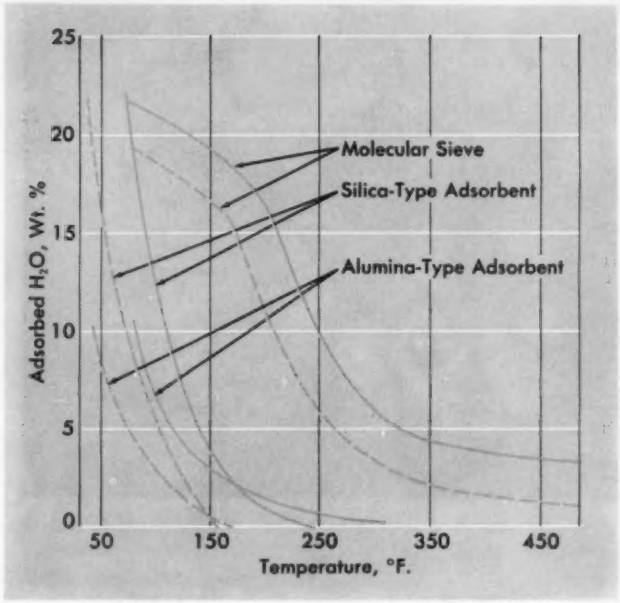


Fig. 2 — Molecular Sieve Compared With Other Types of Adsorbers. Since large amounts of water can be removed at comparatively high temperatures, still higher temperatures are needed to reactivate the material. For this reason, specially designed equipment is generally necessary

it is composed of numerous atoms arranged in a structure similar to the model in Fig. 1.

Molecular Sieves are manufactured by a hydrothermal process. The zeolite is first crystallized as a sodium alumino-silicate (Type 4 A). It can then be ion-exchanged with calcium to produce Type 5 A. Water of hydration is removed by heating. When the water is driven off, the crystal does not collapse or rearrange itself. Instead, the physical structure remains unchanged, a network of uniformly sized pores appearing in place of the vanished water. These openings act as screens which trap or adsorb any molecules in the vicinity which fit into them. Sieve openings are measured in Angstroms with Type 4 A sieves having 4-Angstrom openings, Type 5 A, 5 Angstroms, and Type 13 X, 9 Angstroms. The volume of these spaces is approximately equal to the volume occupied by the crystalline material itself.

Selective Separation Is Possible

Because of the precise uniformity of pore sizes and the unique surface adsorption properties, gases or liquids may be selectively separated and dried. For example, water may be removed from hydrogen, CO_2 may be removed from nitrogen, or ammonia may be removed from hydrogen-nitrogen gas.

When Molecular Sieves have become saturated to equilibrium with surrounding conditions, they can be desorbed by raising their temperature and purging to flush out the desorbed molecules. The amount of any given material that is adsorbed will vary with the vapor pressure of the adsorbate, and the temperature at which the operation is performed.

Actual experience has demonstrated that Molecular Sieves will out-perform other adsorbent materials. Although somewhat higher in cost per pound, they are highly practical and economical because their adsorption capacities generally exceed those of other adsorbants and because they can readily be desorbed and reactivated after saturation. In properly designed equipment, Molecular Sieves will give very long, effective, and economical service records.

As a word of caution, "proper equipment" means dryers or reactivators specifically designed for use with the new material. For example, Fig. 2 illustrates that Molecular Sieves can adsorb large quantities of water even at relatively high temperatures. Therefore, it is apparent that the material must be desorbed at still higher temperatures if it is to be reactivated to its full capacity. When dryer equipment which uses alumina or a silica gel is converted for Molecular Sieves, it is difficult to restore the new desiccant to its full potential. Desorption is incomplete at the temperatures used for other materials. To realize the full advantages of Molecular Sieves, equipment must be engineered specifically for their use.

The first essential when requesting or prescribing data on equipment to be used with Molecular Sieves is accurate figures on load conditions, pressure, temperature, moisture content, and other factors. The necessity for accurate data on loading cannot be stressed too greatly. In the metal industry, this is usually expressed in terms of the dew point of air. Air at -10° F. dew point contains approximately

0.26 grain of water per cu.ft; 0° F. dew point equals 0.44 grain; + 10° F. equals 0.75 grain; and + 40° F. equals almost 3 grains. Since the water content at + 40° F. dew point is more than six times that at 0° F., the amount of Molecular Sieve and the size of the drying equipment to handle influent gases at + 40° F. dew point would be about six times that required to handle the same volume of gas at 0° F. dew point. This point is stressed since the moisture of the gas to be dried has a great effect on the size of equipment and, likewise, on the results obtained. A properly designed dryer using Molecular Sieves should give effluent moisture content in the neighborhood of − 100° F. dew point regardless of the influent dew point.

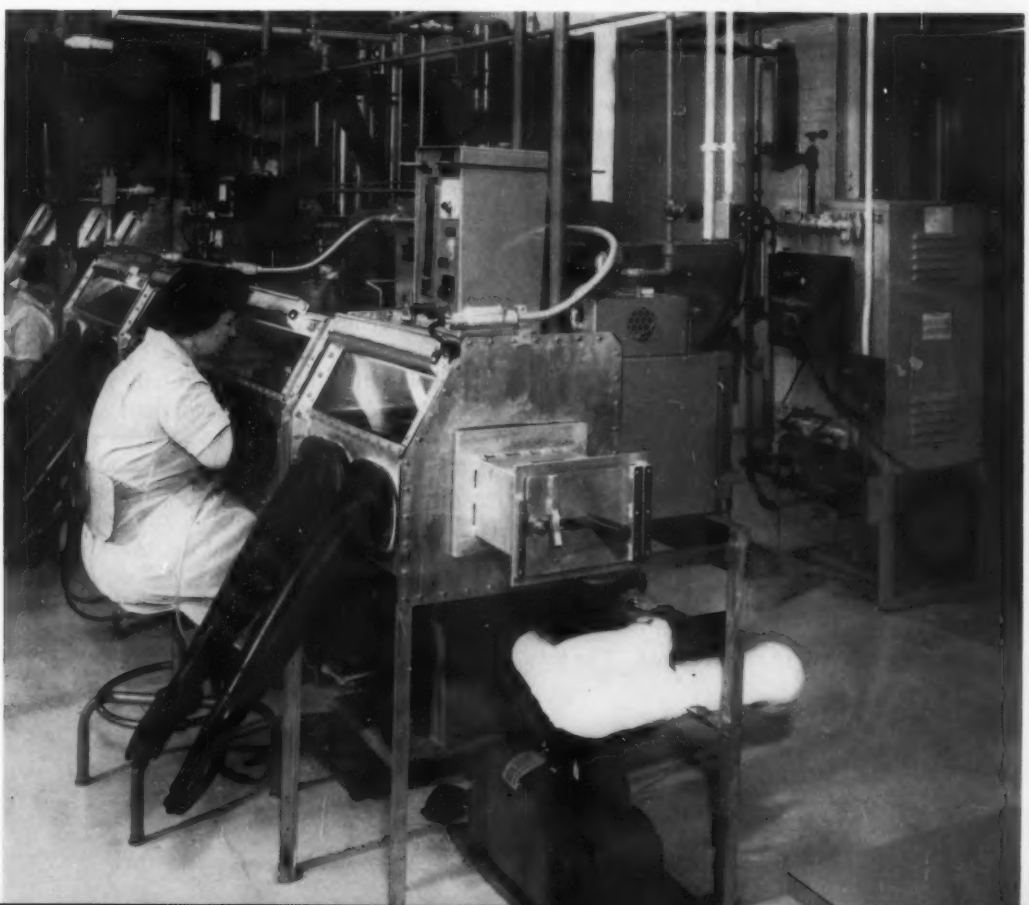
The great potential of Molecular Sieves has challenged equipment manufacturers to design, develop, and produce new equipment. Drying systems are now commercially available and have been installed with gratifying results. New pieces of equipment and systems are being continually developed to meet the growing requirements of industry. Here are a few examples of the Molecular Sieve at work.

Removing Oxygen From Hydrogen

Pure bottled hydrogen is used in heat treating applications where nitriding effects must be entirely eliminated. As bottled, the gas contains some oxygen which, unless eliminated, can discolor the work. Usually, the hydrogen is passed through a platinum catalyst bed. Helped by the catalyst, the oxygen combines with hydrogen to form water vapor. In the deoxidizing process, the dew point rises from about −15° F. to about + 15° F., or 1 grain per cu.ft. When heat treating some materials (such as stainless steels and vacuum tube parts), a gas with a considerably lower water content is often needed. Hydrogen can be dried to − 100° F. dew point by passing it through a desorbed bed of the required depth of Molecular Sieves at the proper temperature, pressure, and flow velocity.

Another example is dissociated ammonia. Though it usually contains a relatively low per-

Fig. 3 – The Dryer in the Background at the Right Side Supplies Dry Air to the Enclosed Sections. In the vacuum oven, partly assembled transistors are baked dry at above 200° F., and finally assembled in an atmosphere containing less than 12 ppm. moisture



centage of water (dew points between − 40° F. and − 60° F.), this hydrogen-nitrogen mixture also will have a certain amount of unwanted ammonia gas – up to 500 ppm. Ammonia is almost as easily adsorbed as water by Molecular Sieves. Thus, when a stream of dissociated ammonia is passed over a properly activated bed of Molecular Sieves, both water and ammonia will be removed. Water will be reduced to less than − 100° F. dew point and the ammonia concentration lowered to under 5 ppm. Since this is a co-adsorption process, it should be re-emphasized that the equipment must be specifically designed to reactivate the bed adequately.

Dissociated ammonia is extensively used as an economical substitute for bottled hydrogen, where the work can tolerate a trace of nitriding. Molecular Sieves can reduce water and ammonia concentration of dissociated ammonia to such an extent that it can be used effectively as a protective atmosphere for stainless steels and other similar alloys.

Dried Air Is Useful

Air which has been dried at either high or low pressures to a very low moisture concentration has a wide range of industrial applications. As an example, dry air has recently been substituted for the more expensive nitrogen which is normally used for "dry box" atmospheres for the assembly and manufacture of transistors. An example is the installation shown in Fig. 3. Installed at Lansdale Tube Div. of Philco Corp., this dryer supplies dry air to the closed-in section of the machine where partly assembled transistors are baked dry in vacuum ovens at over 200° F. with 4-micron vacuum. They are finally assembled in an atmosphere containing less than 12 ppm. of moisture. This assembly consists of cold welding the caps on the transistors with a hydraulic press. Any excess moisture here would raise the electrical conductivity of the air sealed into the transistor body, and alter unpredictably the electrical characteristics so vital to a reliable transistor.

Air dried by the Molecu-Dryer is used in four sealed, glass-paneled cabinets connected end-to-end so that the four operators of this super-clean section can pass the transistors down the line on trays or conveyers. Girls handle the tools and products with arm-length rubber gloves which are sealed at the armhole end to the front wall of each cabinet. The total space in these cabinets is about 50 cu.ft. To replace air lost through airlocks in bringing trays of parts into and finished transistors out of the enclosed area, make-up air is supplied at 3 cu.ft. per min.

Exothermic Gas

Recently, a great deal of interest has been aroused regarding the use of Molecular Sieves for the adsorption of CO_2 and water vapor from exothermic gas. This could be important in heat treating processes. Recent tests have proven that impact strength of hardened steels is increased when such steels are treated in this atmosphere. Though it is still a little early to evolve a theory that completely accounts for the greater toughness of steels so treated, it is clear that eliminating CO_2 and water vapor (which minimizes any tendency toward decarburization) makes it unnecessary to use the atmospheres containing hydrogen that are produced by an endothermic generator. The dry nitrogen, plus a little carbon monoxide, protects the steel without disturbing its structure.

However, to obtain these results it is necessary to use the correct equipment. Exothermic gas usually has a dew point of + 70 to + 80 F., and may have a CO_2 content of 10%. To remove all this water and CO_2 would require a dryer with a chamber containing some 2400 lb. of Molecular Sieve for each 1000 cu.ft. per hr. of the flow of exothermic gas, operating on a normal 8-hr. cycle. The initial cost of installing equipment of this size would be prohibitive. Instead, it has been necessary to install not an ordinary gas dryer, but a complete gas generating installation. This system includes Molecular Sieves arranged so that the desiccant may cycle through its adsorption and desorption stages every 30 to 60 min. Such rapid cycling reduces the over-all size of the installation to one-sixteenth or one-eighth the size which would be required on an 8-hr. basis.

This article has discussed only a few applications of Molecular Sieve drying which are frequently encountered in industry. More unusual applications of drying, purifying, and recovering of gases and liquids are either under engineering study or have just recently been put into service. In the meantime, industrial engineers continue to work in close cooperation with specialists experienced in the design of equipment to house the sieves. The benefits of this kind of teamwork are limitless.

A New Class of Lead-Base Alloys

By D. N. WILLIAMS,
J. A. HOUCK
*and R. I. JAFFEE**

Experimental work indicates that dispersing a metal powder in lead improves its tensile properties. Made by stirring powders of low solubility such as copper, nickel and cobalt into molten lead, the new alloys show promise in extending the usefulness of the heavy metal. (C5r, Q27a, R6g; Pb)

LEAD HAS TWO CHARACTERISTICS which are relatively unusual in a metal – low melting temperature (621° F.) and low solubility for most of the other metals. This has led to the concept of forming two-phase alloys of lead and another metal by direct mixing of molten lead and finely divided powdered metal. Such alloys might prove useful from the standpoint of improved properties of the lead base and some special characteristics of the second phase additive.

An exploratory study of the feasibility of forming alloys of this type – referred to hereafter as lead-cemented alloys – has been conducted at Battelle Memorial Institute in cooperation with the Lead Industries Association. Results of this study are presented here.

Selection of Alloying Materials

Lead-cemented alloys are prepared by direct mixing of a finely divided solid phase in molten lead. This procedure will work satisfactorily only if certain requirements are met. Foremost among these are low solubility and good wettability. It is essential that the finely divided solid material not dissolve in molten lead to any appreciable extent. At the same time, to enhance mixing of the solid and liquid phases, good wettability is required. This is most easily obtained if a slight degree of solubility exists. Fortunately, a number of metals such as cobalt, copper, iron, molybdenum, nickel and tungsten show the requisite low solubility in molten lead for satisfactory alloying. All of these metals are easily obtainable in powdered form.

The composition of the lead phase could also be varied over a considerable range, with either alloying elements completely soluble in both liquid and solid lead or with alloying elements which form eutectics or precipitates in solid lead. However, the present investigation was limited to the use of an unalloyed high-purity lead base.

Mixing Procedures

The most satisfactory mixing procedure is determined by the amount of solid material to be added. For relatively small additions – up to about 15 vol.% – high-speed propeller mixers are satisfactory. When the amount of solid material is greater, the mixture becomes quite sluggish, with the characteristics of a wet cement. These mixtures are best prepared by use of a slowly revolving crucible modeled after a cement mixer. A drawing of equipment for preparing lead-cemented alloys having

*Nonferrous Physical Metallurgy Div., Battelle Memorial Institute, Columbus, Ohio.

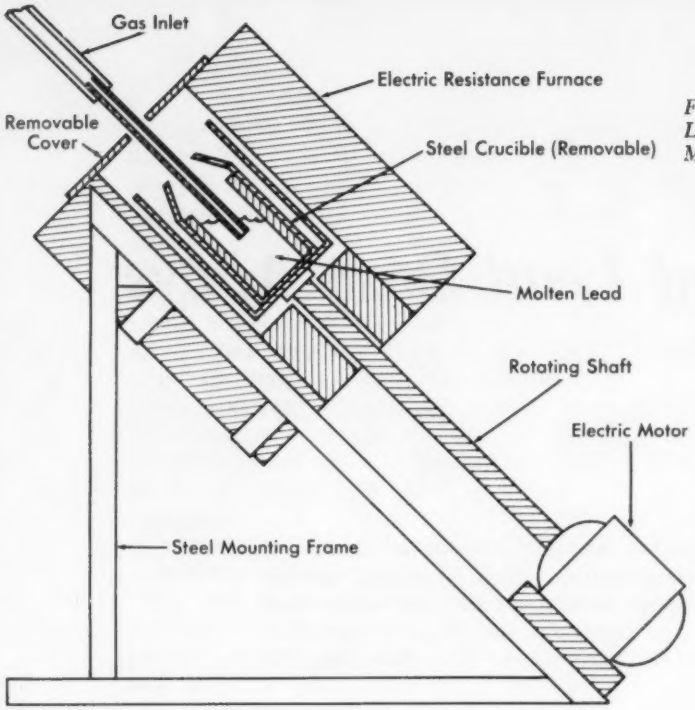


Fig. 1 – Apparatus Used to Prepare Lead-Cemented Alloys Containing More Than 15 Vol.% Solid Material

more than 15 vol.% additive is shown in Fig. 1.

Some of the metals – notably copper and nickel – stir quite easily into molten lead. Others, however, resist mixing attempts because of an oxide film on the powder surface. By reducing the oxide with hydrogen, and mixing under hydrogen, these difficulties were overcome. (Note provision for maintaining a hydrogen flame over the melt in Fig. 1.) These procedures in conjunction with a high mixing temperature permitted the introduction of a number of metals into molten lead.

The amount of powder added to the lead was varied from less than 15 to more than 50 vol.%; it was added directly to the melt, a small amount at a time, until mixing was complete.

Characteristics of the Alloys

The dispersion of solid metal powder in molten lead was cast directly from the mixing crucible into an ingot mold and solidified rapidly to prevent gravity separation. Porosity was minimized by vibrating the mold at low frequency until the metal solidified. After being scalped to remove surface defects, the ingots were extruded to rod at 500 to 550° F. Extrusion of the alloys generally proceeded satisfactorily. If mixing was incomplete, however, so that pockets of unwet powder were present in the ingot, severe surface cracks often formed during extrusion.

Metallographic examination of the extruded bars shows that the cemented alloys consist of a uniform dispersion of metal powder in a lead matrix. No deformation of the metal powder seems to occur during extrusion. Figure 2 shows a typical structure. Very little of the metal powder dissolves during mixing but some agglomeration of particles is evident.

Table I – Tensile Properties of Several Lead-Cemented Alloys*

Composition	Strength	Elongation	Reduction of Area
Unalloyed lead	1940 psi.	65%	98%
Nickel, 30 vol.%	5150	12	22
Nickel, 15	2480	10	15
Copper, 30	4050	6	9
Tungsten, 30	4450	14	26
Iron, 30	1670	5	6
Cobalt, 30	3110	9	19
Cobalt, 18	4820	12	26

*0.505-in. bar samples tested at a crosshead speed of 0.02 in. per min.

As shown in Table I, metal powders generally improve the tensile strength of lead. Excessive agglomeration apparently caused the low strength of the cemented alloy which contains iron.

Although a complete study of the effect of powder size, shape and amount on tensile strength was beyond the scope of this investigation, some interesting trends are apparent in the data given in Table I. An optimum composition seems to exist for each powder used.

Table II – Corrosion of Lead-Cemented Alloys in H_2SO_4 at 140° F.

Composition	Weight Loss in 96 Hr.*	
	40% H_2SO_4	95% H_2SO_4
Unalloyed lead	0.092 g./sq.in.	4.887 g./sq.in.
Copper, 30 vol.%	0.156	14.510
Cobalt, 18	0.112	1.820
Tungsten, 30	0.170	4.960

*Sample size, ½ in. diameter by 2 in. long.

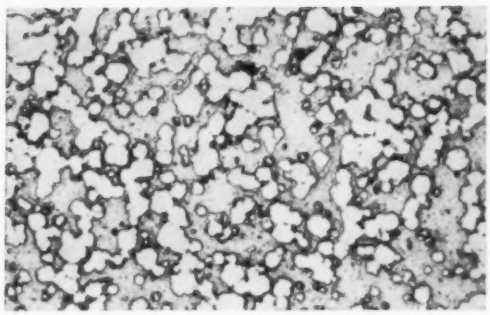


Fig. 2 – Typical Structure of an Extruded Lead-Cemented Alloy. This one contains 30 vol.% Ni. Although nickel particles have agglomerated to some extent, their shape is not changed by extrusion. 250 ×

For example, an alloy of 18 vol.% Co is superior to one containing 30 vol.% Co, but 30 vol.% Ni is superior to 15 vol.% Ni. Also, properties are improved most when a more spherical powder shape and a finer particle size are used. Results obtained in this study suggest strongly that amount, size and shape of the powder are appreciably more significant in controlling tensile properties than composition of the powder.

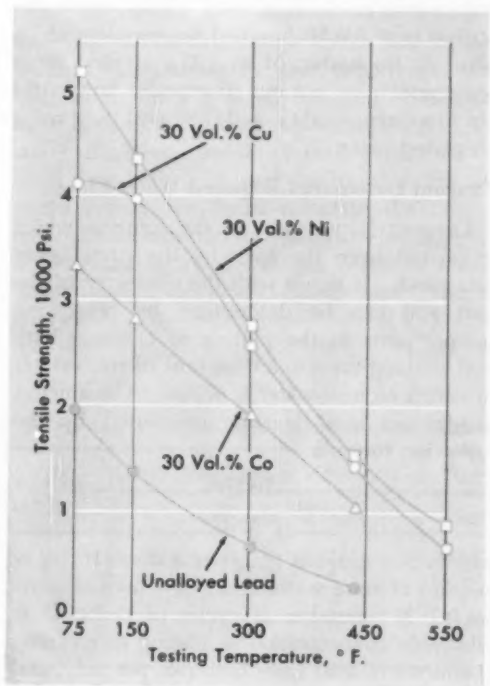
The tensile properties of several cemented alloys as a function of temperature were also determined. Representative data are given in Fig. 3. The ability of the lead-cemented alloys to retain strength at elevated temperature is of considerable interest. If a similar benefit is observed in creep loading (no creep studies have been made), alloys of this type should raise the upper temperature limit to which lead alloys can be used.

Measurements were also made to determine the effect of the dispersed metal phase on the resistance of the alloys to corrosion in sulphuric acid at two concentrations, 40 and 95 vol.%. These data are shown in Table II. Corrosion resistance of the lead-cemented alloys is generally inferior to that of unalloyed lead. However, the corrosion rate decreases more rapidly with time in the cemented alloys than in unalloyed lead, possibly due to the dispersed powder which may cause tight adherence of the corrosion product. One alloy with 18 vol.% Co was superior to lead in 95 vol.% sulphuric acid concentration.

Extruded lead-cemented alloys machine better than unalloyed lead. This suggests the possibility that these alloys may be amenable to joining with threaded joints.

The present study was intended to show the feasibility of producing a new class of lead alloys, the lead-cemented alloys. The next step is to develop alloys toward specific uses. For example, the data already available suggest that certain alloys may be especially useful in the chemical industry as corrosion resistant alloys capable of bearing greater stresses at higher temperatures than present alloys. The structures may also be of interest in bearing-metal applications. Alternately, applications may be based upon some special characteristics of the dispersed phase – the magnetic characteristic of iron powder, for example – with lead serving principally as a binder to permit easy casting and fabrication. Most materials, both metallic and nonmetallic, could probably be made sufficiently wettable to permit their introduction into lead. Or perhaps special uses may be developed which are uniquely suited for these alloys. A hypothetical example is a duplex radiation shielding material for use at elevated temperature, where both components of the alloy provide a specific shielding characteristic, and the structure of the alloy provides the necessary resistance of flow.

Fig. 3 – Tensile Strength of Several Lead-Cemented Alloys as a Function of Temperature



Progress in Finishing

How to Determine Requirements for

Reduced costs in rinsing operations can be achieved by applying some basic principles. Here is an example. (L12e, L17)

ELECTROPLATERS see many of their profit dollars go down the drain as waste water from processing operations. Complying with rigid antipollution laws is expensive whether you are constructing new plating facilities or trying to hold down production costs. This article describes how I.B.M. handled the problem at its plant in Rochester, Minn. We applied some basic principles, cut our rinse water flow without sacrificing quality, and increased our profits on plated parts.

Dragout Determines Required Water Flow

Dragout is that part of the solution which is carried from the bath by the parts being processed. It varies with the geometry of the part and can be determined by processing sample parts in the plating or cleaning bath and washing them in a rinse tank of fresh water to which no new water is added. The amount of dragout can then be calculated by the following formula:

$$S = \frac{1000VC_t}{ANC_o}$$

where: S = dragout (gal. per 1000 sq.ft.), V = amount of rinse water (gal.), A = area of parts (sq.ft.), N = number of cycles or racks, C_t = allowable concentration of plating or cleaning chemicals in final rinse bath (oz. per gal.), and C_o = concentration of plating or cleaning solution (oz. per gal.). Typical dragout figures for flat parts are as follows*:

Vertical parts, well drained	0.4 gal. per sq.ft.
Vertical parts, poorly drained	2.0
Vertical parts, very poorly drained	4.0
Horizontal parts, well drained	0.8
Horizontal parts, very poorly drained	10.0

The concentration of contaminant in the water remaining on the parts is a measure of the effectiveness of the rinse. The allowable concentration (C_t) must be pre-established by considering the effect of contaminating ions (dragover) in subsequent plating solutions. Rinsing after a hydrochloric acid bath prior to chromium plating must be thorough; in our process C_t must not exceed 0.002 oz. per gal. Rinsing after an acid dip prior to copper plating is not as critical; C_t equal to 0.1 oz. per gal. is permissible here. The concentration of the plating and cleaning solutions must be firmly established.

*Source: Electroplating Engineering Handbook, by A. K. Graham, Reinhold Publishing Co., New York, 1955.

Rinse Water in Plating Processes

*By H. W. PARKER**

Our experience shows that good design of a rinsing system calls for a water flow from tank to tank opposite to the movement of parts. Agitation and spray equipment improve the rinse effectiveness.

A simplified formula for calculating the rate of flow in a countercurrent system is:

$$F = \frac{S}{t}\left(\frac{C_o}{C_f}\right)^{\frac{1}{n}}$$

where: F = rate of flow of fresh water (gal. per min.), t = time interval between rinsing operations (min.), and n = number of rinse tanks. (S, C_o, and C_f were defined previously.)

Results of sample calculations are shown in Table I. The figures show the beneficial effect of countercurrent flow and multiple rinsing especially where the ratio of $C_f : C_o$ is low.

In our plating department we had expected a water flow of 875 gal. per min. By application of this method, we reduced the water needed to 200 gal. per min. In one chromium plating line, we cut the water flow from an expected 159 gal. per min. in a single rinse tank to 0.85 gal. per min. with countercurrent flow in two tanks. We considered past experience, part geometry, and estimated dragout. Since the plating or cleaning bath concentration (C_o), the allowable concentration of contaminant in the final rinse bath (C_f), and the transfer time (t) were known, we could calculate the rate of flow (F) for any number of tanks (n).

Our final figure of 200 gal. per min. for all our operations includes a safety factor and an allowance for future expansion of 100 gal. per min.

*Advisory Engineer, Materials Laboratory, International Business Machines Corp., Rochester, Minn.

Table I — Rinse Water Requirements in Single and Multiple-Tank Countercurrent Systems

Bath	Concentration, C_o	Concentration of Contaminant, C_f	Water Required for Equivalent Rinse		
			3 Tanks	2 Tanks	1 Tank
Chromium	53.0 oz. per gal.	0.002 oz. per gal.	1 gal. per min.	5.7	889.0
Cyanide	13.1	0.005	1	3.7	189.0
Cleaner	4.0	0.1	1	1.9	11.7
Acid	32.0	0.1	1	2.6	47.0
Acid	32.0	0.002	1	5.1	635.0

Heat Treating Electroless Nickel Coatings

By K. T. ZIEHLKE,
W. S. DRITT
*and C. H. MAHONEY**

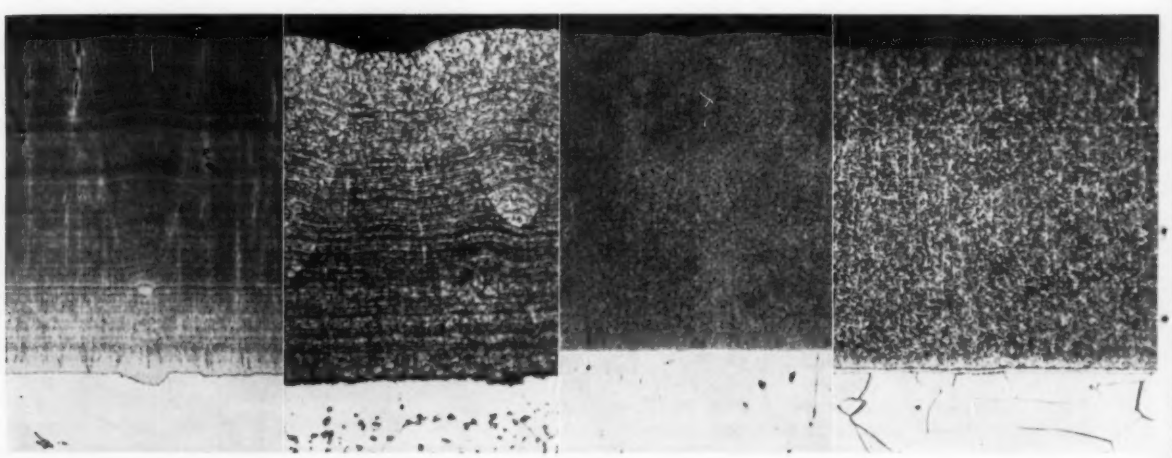
Electroless nickel coatings containing 7 to 10.5% phosphorus can be heat treated to obtain various hardness and ductility combinations. The maximum hardness (1000 dph.) is independent of phosphorus content and occurs during the formation of an interim lattice from the amorphous structure of the as-deposited plate. (Q29, Q23p, 2-64, L28; *Ni*)

ELECTROLESS NICKEL, a chemically deposited alloy of nickel and phosphorus, has corrosion resistance in most environments equivalent to that of wrought nickel. The plating, which is amorphous in the as-deposited condition, is nonporous even in very thin layers. It will cover intricate surfaces uniformly. The as-deposited plate consists of laminations parallel to the basis metal (Fig. 1, left). Hardness is 500 to 600 dph. (Rockwell C-50 to 55).

Although it is known that the nickel-phosphorus coatings are heat treatable to high hardness, no work has been reported which relates various heat treatment cycles with hardness.

*Technical Div., Oak Ridge Gaseous Diffusion Plant, Union Carbide Nuclear Co., Oak Ridge, Tenn. This document is based on work performed at the Oak Ridge Gaseous Diffusion Plant operated by Union Carbide Corp. for the U.S. Atomic Energy Commission.

As Plated *750° F.* *930° F.* *1110° F.*



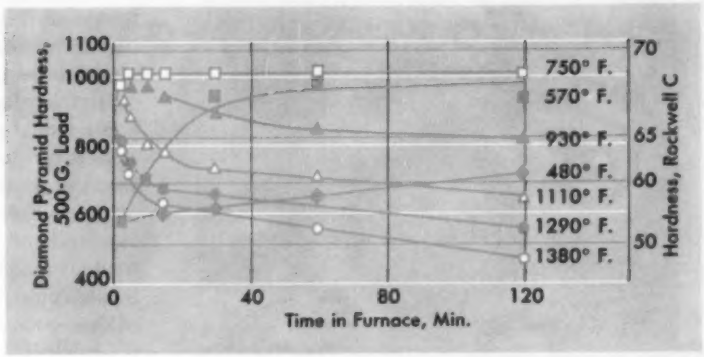


Fig. 2 – Effect of Heat Treatment on the Hardness of Electroless Nickel Plate (8.5% Phosphorus). Heat treatment was carried out in air in a thermostatically controlled furnace

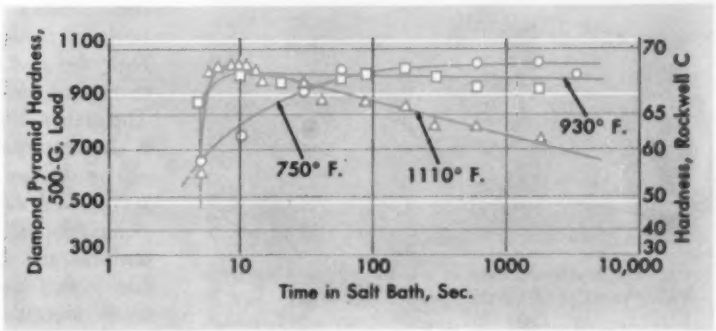


Fig. 3 – Short-Time Heat Treatment Response of Electroless Nickel Plate (8.7% Phosphorus). Heat treatment was carried out in a salt bath

At the Oak Ridge Gaseous Diffusion Plant, the response of electroless coatings to heat treatment has been studied over a wide range of times and temperatures. Combinations of hardness and ductility best suited to a specific job are readily obtained by proper selection of the heat treatment cycle. The effect of phosphorus also has been evaluated over the range encountered in commercial electroless nickel deposits.

Samples included in the survey were plated on mild steel and S.A.E. 52100 steel. They were cut from larger disks to give a plated area of about ½ sq.in. Phosphorus contents were at first determined by wet chemical analysis. Techniques developed later permitted direct spectrographic determination of phosphorus.

1380° F.

Fig. 1 – Effect of Heat Treatment on the Structure of Electroless Nickel Plate (8.5% Phosphorus). Laminations in the as-plated structure are eliminated and agglomeration occurs as temperature is increased. Time at temperature, 1 hr.; etchant, sodium cyanide - ammonium persulphate. 500 ×

Changes in Microstructure

No changes in microstructure were seen in samples heat treated below 750° F., although hardness increased from the as-deposited level to a peak of about 1000 dph. Above 750° F., precipitation and agglomeration can be detected. Agglomeration becomes pronounced with increasing temperature and time of heat treatment. It is more rapid in coatings with low phosphorus.

Photomicrographs in Fig. 1 show the change in structure which occurs when coatings containing 8.5% phosphorus are heated at various temperatures for 1 hr. The laminated structure of the as-deposited plate is still prominent after heat treating at 750° F. to obtain maximum hardness. At 930° F., laminations are much

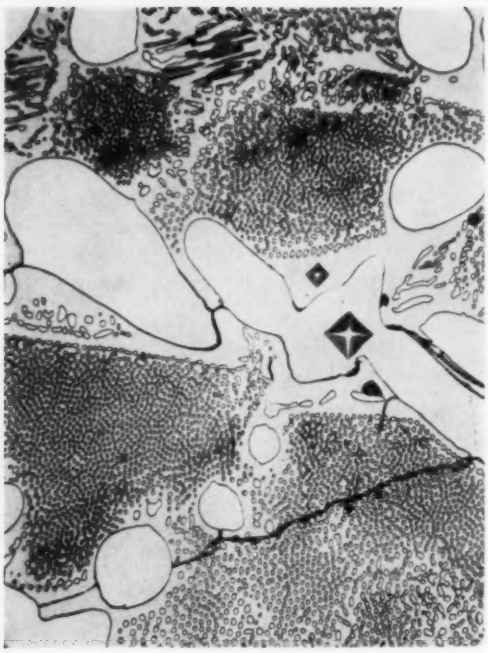


Fig. 4 – Microstructure of a Cast Nickel Alloy (9% Phosphorus). Dendritic phase (α nickel) has a hardness of 190 dph. and continuous phase (Ni_3P), 760 dph. with a 25-g. indenting load. Etchant, sodium cyanide-ammonium peroxide; 500 ×

less prominent and a precipitate has appeared. The precipitate has started to agglomerate at 1110° F. and hardness has dropped to 725 dph. Clearly resolvable particles are present in the microstructure after heat treatment at 1380° F.

A summary of the heat treatment response of a coating containing 8.5% phosphorus is given in Fig. 2, covering times from 3 min. to 2 hr. in air in a thermostatically controlled furnace. The very short time response of a series of samples containing 8.7% phosphorus was studied by heat treatment in a salt bath. These data are summarized in Fig. 3.

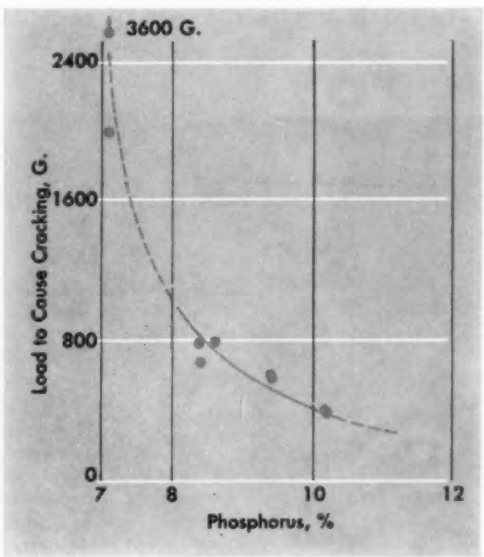
Hardening Mechanism

Electroless nickel is amorphous in the as-plated condition. Such a deposit might be expected to be structurally unstable, and responsive to heat treatment, even at low temperatures. The approach to peak hardness in the first stage of heat treatment can be attributed to the establishment of an interim crystal lattice in the initially amorphous deposit. Only a small amount of atom movement is required to form this lattice from the amorphous structure since no diffusion is required. At high temperature the transformation is rapid. The transformation is exothermic, indicating the establishment of an ordered structure.

High hardness of the newly established lattice arrangement is probably due to distortion caused by the nonequilibrium locations of the atoms of nickel and phosphorus. As heat treatment continues, atoms diffuse to more stable locations and hardness drops. The sample heat treated at 1380° F. (Fig. 1) is approaching equilibrium; its structure is comparable to that of slow cooled cast alloy (Fig. 4) containing 9% phosphorus. This discontinuous phase is a solid solution of phosphorus in nickel in the range of phosphorus contents under study. In both the cast and plated samples it is harder than pure nickel (about 200 dph. vs. 75 dph.). The matrix, Ni_3P, is hard (800 dph.) and brittle, a characteristic of intermetallic compounds.

The diffuse halo pattern that has been observed in X-ray reflection studies of the amorphous deposit gradually sharpens with low-temperature heat treatment as the interim lattice is formed. Nickel lines can be positively identified in the halo background after 15 min. at 570° F. The X-ray identification of Ni_3P in this structure is more difficult, because

Fig. 5 – Influence of Phosphorus on Ductility. All samples are in the hardness range 760 to 835 dph. (Rockwell C-63.0 to C-65.4). Ductility is measured by the load on the indenter which causes cracking around the hardness indentation



of a large number of other lines (probably higher phosphides). Lines identified as Ni_3P intensify in samples heat treated at 750° F., and the interfering lines become fewer and weaker in intensity with advancing heat treatment. Above 750° F. the halo pattern disappears rapidly. Evidence of grain growth in both nickel and Ni_3P can be seen in samples heat treated for an hour at 1110° F.

Effect of Phosphorus

Phosphorus does not seem to play an important part in the early response of electroless nickel to heat treatment. For example, when samples with three different phosphorus contents (7.2, 8.7, 10.3%) are heated at 1110° F., all of them reach the same hardness peak (1000 dph.). After the peak has been reached, phosphorus has a pronounced effect. Thus, a 2-hr. treatment at 1110° F. reduced the hardness of a sample containing 10.3% phosphorus from 1000 to 790 dph. In the same time the plate with 7.2% phosphorus softened to 580 dph.

Softening that occurs with prolonged heat treatment depends on co-precipitation and agglomeration of nickel and nickel phosphide from the pseudostable interim lattice. The hardness of the coatings after prolonged heat treatment appears to be a function of the amount of hard Ni_3P present.

One of the drawbacks of electroless nickel coatings is the weakness inherent in the laminated structure. That the laminations can be eliminated by heat treatment and that they are more readily eliminated in coatings of lower phosphorus content because of more rapid agglomeration of the constituent phases are pertinent advantages of heat treatment.

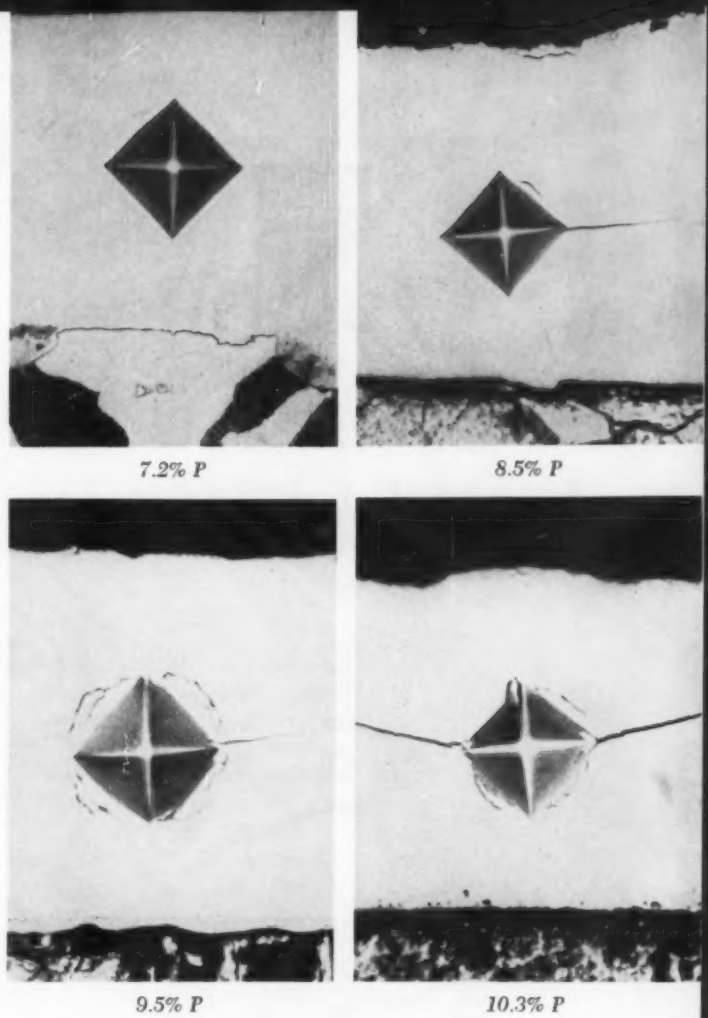


Fig. 6 – Comparative Ductility of Electroless Nickel Coatings of Various Phosphorus Content. Samples were indented with a Vickers diamond under a 700-g. load. The degree of cracking around the indenter is a relative measure of ductility. Hardness of the coatings is in the range 735 to 810 dph. (Rockwell C-62 to C-64). 500 ×

Ductility

Early in the test program, it was difficult to obtain crack-free hardness indentations in the hard coatings. It was found that the indenting load required to crack the coatings is related to the hardness and phosphorus content. This correlation suggested that the load required to cause cracking could be taken as a measure of the ductility of the samples. For example, Fig. 5 shows the ductility as measured by the minimum indenter load which would cause cracking, plotted against phosphorus content. This figure shows that, at a given hardness level, ductility decreases as the phosphorus content increases. The degree of cracking under constant indenting load also changes with phosphorus content. This change is illustrated in the series of photomicrographs in Fig. 6. Cracking is most severe in the sample containing the most phosphorus (10.3%). Thus, at equivalent hardness levels, nickel coatings of low phosphorus are more resistant to chipping and shattering than those of high phosphorus content.

Work is continuing on coatings with phosphorus contents below 7%, with a view toward obtaining high hardness without sacrificing ductility. Studies are also being conducted to determine the effects of variations in phosphorus content and heat treatment on the corrosion resistance of the coatings.

Staff Report

*Cleaning Missile Tanks by Vapor Degreasing**

Developed for cleaning the interior of liquid oxygen tanks for missiles, closed-system vapor degreasing is now catching on in the trucking industry. Tank truck operators find the new method does the job of removing asphalt, mineral, vegetable and animal oils, fats, most resins and plasticizers from tank walls much more quickly and economically than the old batch method. (L12j)

ENGINEERS at Douglas Aircraft and Detrex Chemical Industries, Detroit, have come up with a unique method for cleaning the interiors of liquid oxygen tanks for one of our large missiles by vapor degreasing with trichlorethylene. Cleanliness is important here because the presence of organic material in oxygen tanks could lead to explosions or fouling of critical missile valves.

Cleaning is carried out at Douglas' Santa Monica plant in tall towers in which the tanks can stand vertically (Fig. 1). Tanks are moved on dollies from the production line to one of the towers. There the dolly is hinged to the base of the tower and raised to put the tank in a vertical position inside the tower. The dolly is then disengaged and lowered.

Hydrostatic and calibration tests are conducted with filtered water containing sodium dichromate. After these tests, the tank is drained, rinsed, and purged with clean, heated air until dry.

Source of the cleaning vapors is a vapor generator – specifically designed for this job – located outside the towers. The missile tank and generator form a closed system. Trichlorethylene is heated in a vapor generator to about 180 to 190° F. and the vapors are piped into the bottom of the missile tank which fills in about 1 hr. Cleaning continues from this point for another 30 min. as the vapors condense on the interior walls of the tank. Droplets pick up impurities when they collect and drain to a flanged extension at the bottom of the tank. The liquid trichlorethylene is returned to the vapor generator and distilled for reuse. Losses are small. When the cleaning operation is completed and all the liquid has been removed, the tank is again purged for 30 min. with warm air until dry and odor-free. All openings are then sealed, the tank is lowered in its dolly, and returned to the production line.

Process Applied to Truck Tanks

This general technique for cleaning large missile tanks is now being adopted by the trucking industry for cleaning truck tanks. Trichlorethylene has been employed for some time in vapor degreasing interiors of tanks which have

*Prepared from material supplied by Detrex Chemical Industries, Inc., Detroit, and Douglas Aircraft Co., Inc., Santa Monica, Calif.

Fig. 1 — Tall Towers House Missile Tanks During Hydraulic Tests and Vapor Degreasing at Douglas Aircraft's Santa Monica Plant

carried asphalt, mineral, vegetable and animal oils, and fats. However, the process has been comparatively uneconomical. In the past, all of the contaminated trichlorethylene was discarded (about 40 gal. per 5000 to 7000-gal. tank). The solvent was heated in batches in a separate tank and the vapors were carried to the truck tank in a flexible metal hose. Cleaning required at least 2 hr.

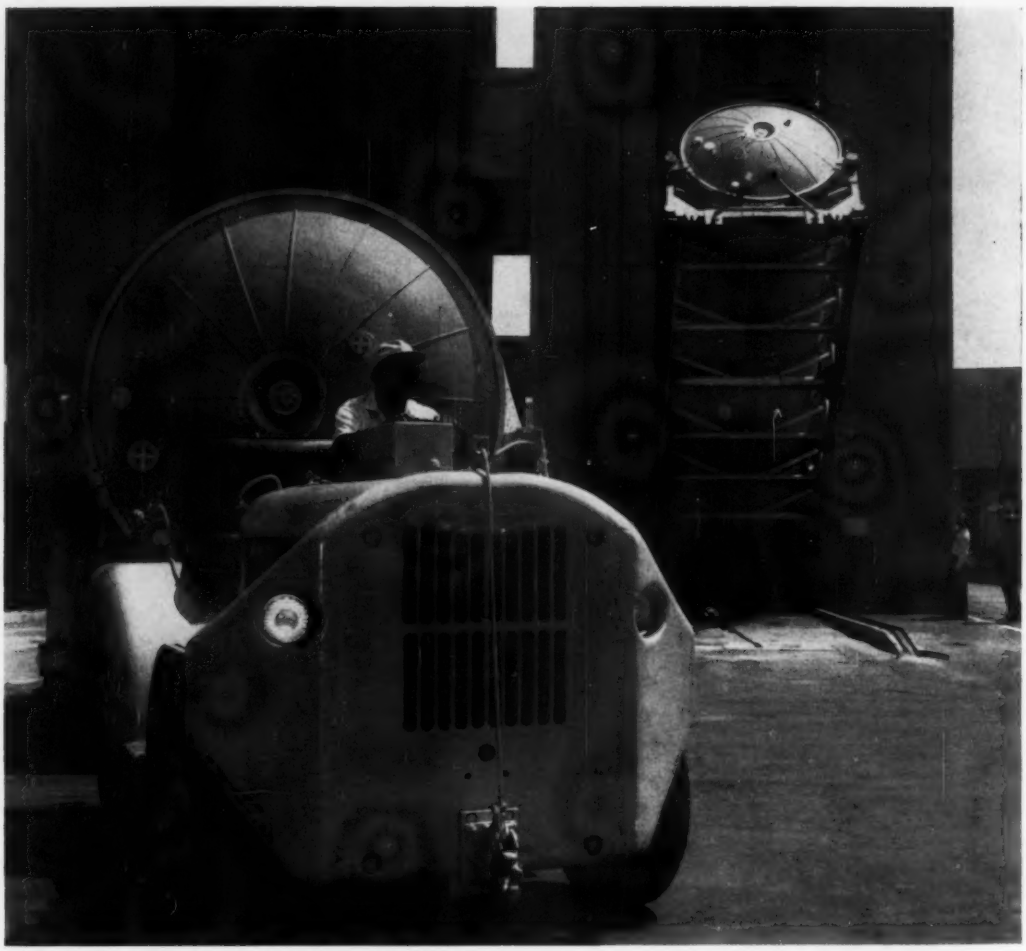


Fig. 2 – Missile Tank, Wheeled From Production Line, Is Positioned in One of the Towers (Right) While Still Cradled in Its Dolly. Dolly is then disengaged from the tank and lowered

With the use of the vapor generator, however, the entire cleaning system is continuous. Just as with missile tanks, the trichlorethylene is vaporized in the generator, condensed on the walls of the tank, and is returned as a liquid to the generator boiler (Fig. 3). The contaminated solvent can be purified by distillation in the generator. Cleaning time is only 15 to 20 min. for a 5000-gal. insulated tank. When the cleaning has been completed, the tank contains about 170 lb. of vaporized trichlorethylene. Most of this is reclaimed in a recovery system. Tanks which are used to haul edibles or those which are being prepared for welding should be ventilated.

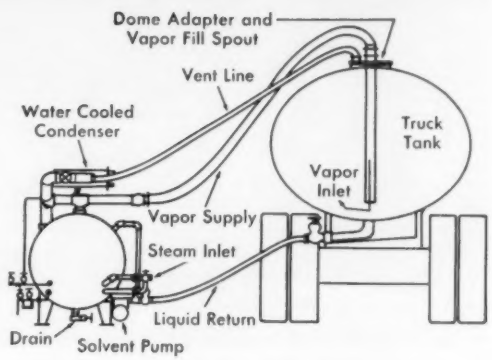


Fig. 3 – Diagram of a Vapor Generator Setup for Cleaning the Interior of a Truck Tank. This is the same technique, on a smaller scale, which is used to clean liquid oxygen tanks for missiles (Fig. 1 and 2). Cleaning vapors enter tank from generator and condense on the walls. Contaminated liquid is pumped out the bottom and returned to the vapor generator for reuse

A Nitriding Steel That Age Hardens

By W. S. MOUNCE
and A. J. MILLER*

This steel contains 5% Ni and 2% Al. It can be nitrided and hardened at the same time by an aging treatment (temperature range, 950 to 1100° F.) in a nitriding atmosphere. The steel is expected to be useful for cams, gears, and shafts that need fatigue and wear resistance at elevated temperatures. (J27d, J28k; AY, *Ni, Al*)

A BASIC STUDY of nickel and aluminum as age hardening agents for steel has resulted in a new alloy which hardens to a minimum tensile strength above 200,000 psi. when aged at temperatures between 950 and 1050° F. Nitriding at these same temperatures also produces a case equivalent to one formed on standard Nitralloy steels. As a result, when used in the nitrided condition, the steel (which contains 5% Ni and 2% Al) provides exceptional fatigue and wear resistance both at atmospheric and at elevated temperatures.

There are other advantages. Since aging

*Mr. Mounce is in applications engineering and Mr. Miller in the research laboratory, development and research division, International Nickel Co., Inc., New York. The authors wish to acknowledge the contributions made to this development by F. B. Foley, C. C. Clark, O. O. Miller, D. L. Pasquine and others of the Inco Research Laboratory.

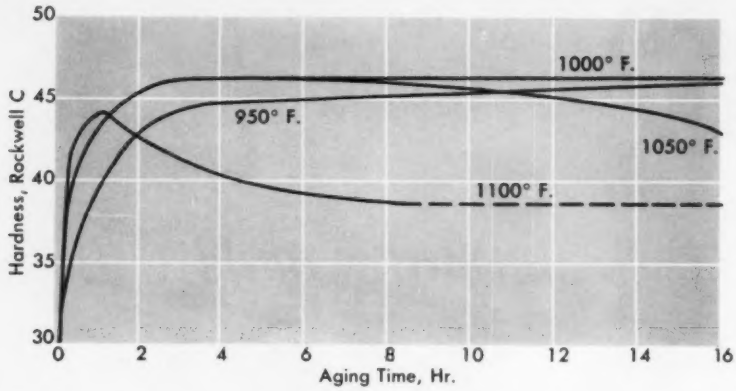


Fig. 1 — Age Hardening Behavior of 5% Ni, 2% Al Steel. Note that full hardening can be achieved within a 100° range. Above 1050° F., the hardness falls off

(rather than quenching) develops these excellent properties, distortion can be lessened in large or complex parts. How is this possible? By machining in the solution treated condition (hardness Rockwell C-28 to 35), then aging to Rockwell C-44 to 48 by a relatively low-temperature treatment. Rapid heating or cooling (or both), which often result in distortion, are not involved in this final hardening.

Steels containing nickel and aluminum that age harden between 950 and 1050° F. have been in commercial use for many years. An elaboration of previous work has now revealed that the final hardness after aging is the result of two effects. A base hardness is first established by the solution treatment, then a further hardness increment is added by aging. This aging increment depends directly upon the nickel-aluminum relationship. It appears that aging in ferritic steels is a result of an ordering reaction in

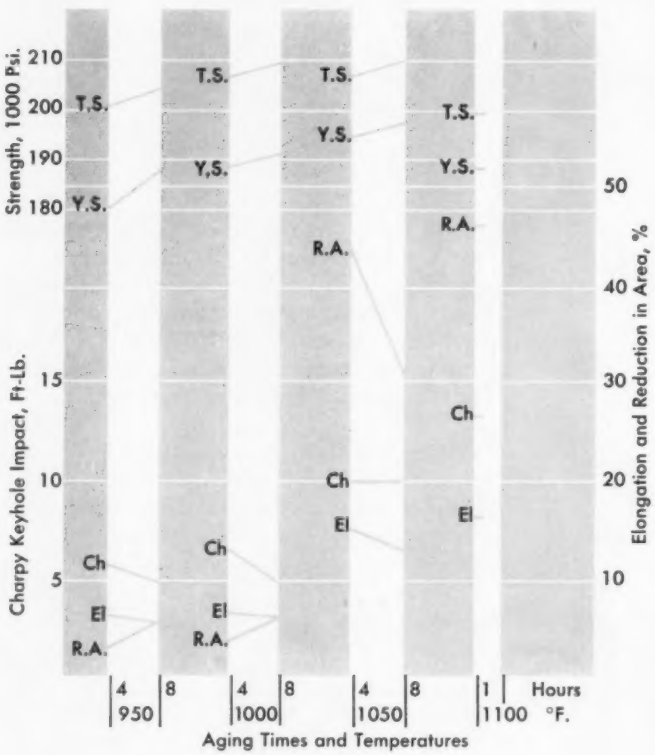


Fig. 2 — Effect of Aging at Different Times and Temperatures. Aging at higher temperatures increases ductility and toughness. However, strength begins to drop when overaging begins

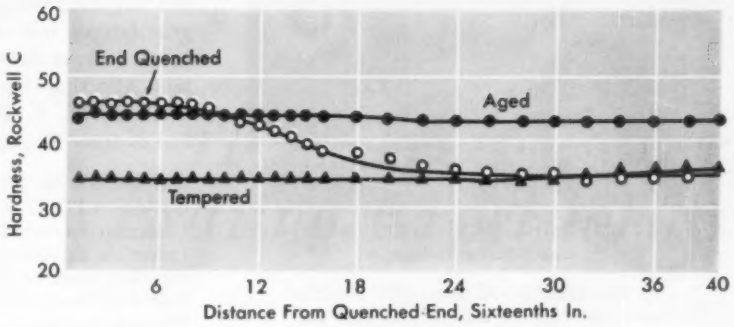


Fig. 3 – Hardness Distribution in End Quenched Bar After Quenching, Tempering at 1275° F., and Aging 8 Hr. at 1050° F.

which nickel and aluminum are operating in a stoichiometric relationship. In this investigation, the optimum properties after aging were achieved with a total nickel-plus-aluminum content of 7% by weight. The most effective combination was 5% Ni and 2% Al. Other combinations are usable within limits. Aluminum is the controlling factor.

Response to Aging

The structure to be aged should be fully quenched and tempered as a prior treatment. If this is not done, ductility and toughness are likely to suffer, though final hardness may not be affected. Tempering, which also constitutes a solution treatment, should be done as close as is practical to the Ac_1 critical temperature; this provides the lowest solution treated hardness, best machinability, and best response to aging. Some aging may occur if the material cools too slowly from the tempering or solution treating temperature. To obtain the best machinability and final properties, sections 2 in. round and smaller can be air cooled, but larger masses may require liquid quenching.

Composition and Heat Treatment

This steel contains 0.20 to 0.25 C, 0.25 to 0.45 Mn, 4.75 to 5.25 Ni, 0.40 to 0.60 Cr, 0.20 to 0.30% Mo, 1.80 to 2.20 Al, and 0.08 to 0.15 V. To reach its full strength and toughness, it is normalized at 1700° F., oil quenched from 1650° F., solution treated at 1275° F., and aged at 1050° F., for not less than 5 hr.

Figure 1 shows how the steel responds to aging within the 950 to 1100° F. range. It is evident that this steel has a wider range of aging temperatures and resists "overaging" to higher temperatures than do lower nickel-aluminum steels. These characteristics are commercially important. They mean that the steel develops maximum core properties when nitrided with Floe cycles that may go as high as 1050° F.

The "overaging" shown at 1100° F. and above is believed to be a re-solution effect. A hardness that is characteristic of the aging temperature is established in a rather short time. Once stabilized, however, the hardness does not decrease further with time. During creep tests, a specimen aged to Rockwell C-44 at 1050° F. showed no change of hardness after being exposed at 900° F. for 10,000 hr.

The tensile and impact properties obtained

Table I–Nitriding Cycles for 5% Ni, 2% Al Steel

Treatment	Case Depth	Rockwell Hardness	
		Case	Core
A. Floe process, 975° F., 6 hr.; 1025° F., 30 hr.	0.015 in.	15 N-93	C-45
B. Chapman Ni-20* 1020° F., 20 hr.	0.012	15 N-93	C-46
C. Nitro Cycle pressure nitriding† 7.5 g. per sq.ft. NH_4, 1000° F., 15 hr.	0.010	15 N-93.3‡	C-45.5‡
53 g. per sq.ft. NH_4, 1000° F., 21 hr.	0.015	15 N-93.3‡	C-45.5‡
D. Gas nitrided, 975 to 1000° F. 24 hr.	0.012	15 N-92.5	C-49.5
48	0.015	15 N-93.2	C-49.2
48 (0.0002 white layer)	0.020	15 N-91.4	C-50

*Licensed by Chapman Valve Co.
†Patented process, Oil Well Supply Div., U.S. Steel Corp.
‡By conversion from diamond pyramid hardness.

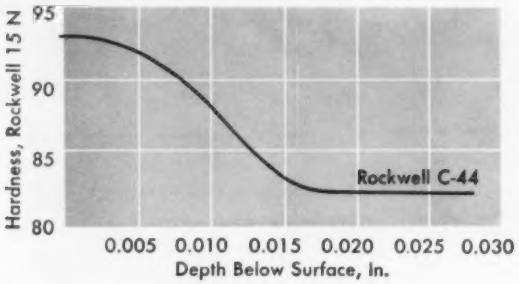


Fig. 4 — Hardness Curve of a Nitrided Case. Composition: 4.97 Ni, 2.03 Al, 0.21 C, 0.31 Mn, 0.49 Cr, 0.26 Mo, 0.095 V

with various aging treatments are shown in Fig. 2. Ductility and toughness are increased by overaging, but at a sacrifice in strength. Hardenability tests also indicate that very uniform hardness should be obtainable over a wide range of section sizes. Aging is practically as effective in the air cooled end of the bars as it is in the thoroughly quenched prior structures. This is shown in Fig. 3. A hardness survey throughout the cross section of a 10-in. cube revealed only nine points variation in Brinell hardness from surface to center after final aging.

Nitriding Characteristics

The steel develops excellent nitrided cases. Figure 4 shows the case hardness gradient of a sample nitrided 26 hr. by a Floe cycle in which the second stage was at 1025° F. The surface hardness was Rockwell 15 N-93, case depth 0.018 in. and core hardness, Rockwell C-44. Table I lists the results of several other nitriding cycles. (It is evident that all cycles are within the temperature range of aging.)

Elevated-Temperature Properties

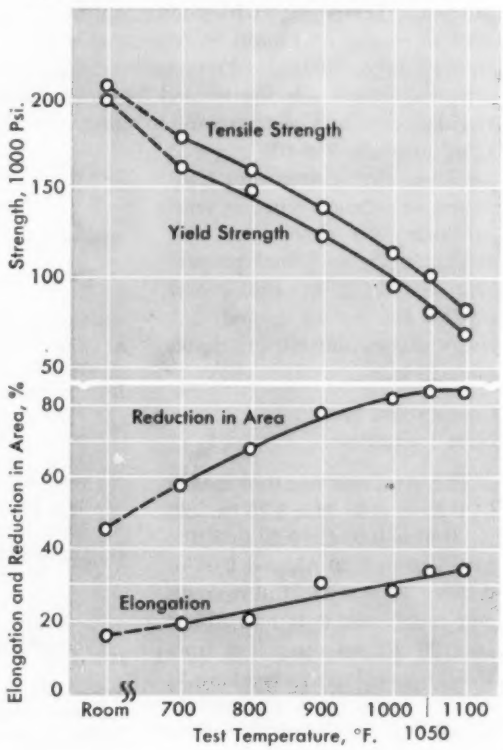
The resistance to tempering demonstrated by both the core and nitrided case has made this steel particularly attractive for cams, gears, shafts and bearings that require fatigue and wear resistance up to 1000° F. As an example of the high-temperature properties, the case hardness will drop from Rockwell 15 N-92 (at room temperature) to Rockwell 15 N-80.2 at 1000° F. and Rockwell 15 N-71.5 at 1200° F. Meanwhile, the core drops from Rockwell C-46 to Rockwell C-25 at 1000° F. The short-time tensile properties of the aged steel (without nitriding) at temperatures up to 1100° F. are shown in Fig. 5.

Various types of fatigue and wear tests at elevated temperatures have shown that this steel has excellent properties. Results of a special gear fatigue test of several materials at 600° F. are as follows (taken from "Investigation of Factors Affecting High-Temperature Gear Operation", by E. E. Shipley, American Society of Lubrication Engineers, 1958):

Nitrided 5% Ni, 2% Al steel	54,000 psi.
Nitrided LPD (fully hardened core)	53,000
Induction hardened M-2	44,000
Induction hardened and nitrided M-2	44,000
Nitrided Nitralloy N	43,000
Nitrided Nitralloy (heavy case)	40,000
Through-hardened and finish ground M-2	30,000
Through-hardened M-2 (some decarburization)	23,000

In conclusion, the results of early trials in the field indicate that this new steel, which can be age hardened and nitrided at the same time, will be very useful in the future. Its improved strength, fatigue and wear resistance are certain to be of value for mechanical parts used at both room and elevated temperatures.

Fig. 5 — Short-Time Elevated-Temperature Mechanical Properties. This material was normalized at 1750° F., quenched from 1650°, solution treated at 1275°, and aged at 1050° F. for 4 hr.



High-Temperature Brazing Experiments

*By R. R. RUPPENDER**

Statistical analysis is suggested as a means of resolving discrepancies in results of similar fusion welding experiments. Details of a typical experiment illustrate the possibilities. (K8, S12)

SINCE ITS INTRODUCTION, brazing has been more an art than a science. Why is this so? One trouble has been that investigators have not recognized one of the most important components of their measurements – experimental error.

About once each year an article or paper hopefully suggests the statistical approach to investigations, but the idea does not appear to have taken hold. Nevertheless, whenever measurements are made, they obey laws of uncertainty and variation. We who develop our professional stature by making engineering decisions in the face of chance would do well to take a long, hard look at the statistical approach.

A common misconception is that averaging several experimental readings automatically yields a good, usable value. This is only partly true. If data have been properly gathered, the average is, of course, the best *estimate* of some true value. But, if widely separated values are averaged, the best estimate may be none too good. No one will deny this; yet without the tools of statistical analysis, we are powerless to do anything scientific about it. Statistical analysis can not only handle experimental uncertainty, but it can actually be used to unravel complex situations involving many variables.

Here's a typical situation. Problem: Compare the strengths of joints obtained when brazed with filler alloys "A" and "B". Current planning might go something like this: "Bitter experience tells me that many variables affect the strength, so many I can only hope to hold them all constant – except those of interest, of course. Around our shop we shoot for 'zero' clearance so I'll continue to do that. Tests are expensive, too, so I'll vary only the filler alloy. I'll test three specimens brazed with each of the two filler alloys. By merely holding all other variables as close as I can, I'll practically eliminate any effects they may have. Anyway, if they do have any effects, that's okay too. I'm 'simulating' production conditions so my results will be that much more realistic and consequently useful."

This thinking yields the following results:

	FILLER A	FILLER B
	42,950 psi.	42,950 psi.
	23,050	44,100
	36,000	45,650
Average	33,333	44,233

Anyone inspecting these data is likely to conclude that filler A joints are 75% as strong as filler B joints. (Of course, the spread of A values, expressed as standard deviation, is ±9240 psi. while that of B is 1350 psi., but who cares about that?)

*Manufacturing Engineer, Flight Propulsion Laboratory Dept., General Electric Co., Cincinnati, Ohio.

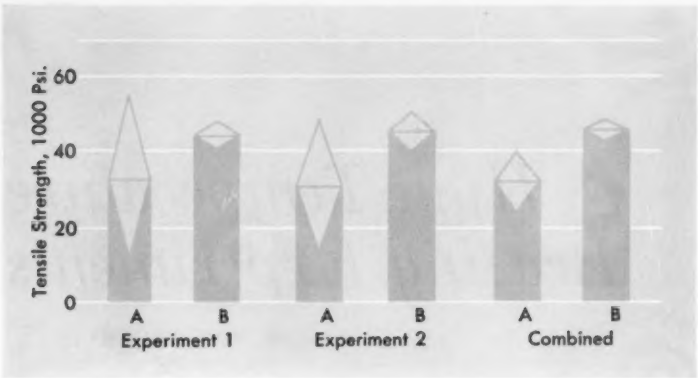


Fig. 1 – Bar Graph of Combined Tests. Diamonds indicate 95% confidence limits

At this point the investigator should ask himself: "If the average values are not perfectly reliable, then how reliable are they? Of what practical use are they? What makes one value more reliable than another? What do my averages represent, anyway?" After a peek into a book on statistics, he can answer: "They are *estimates* of the values which would have been obtained by averaging an infinitely large number of test results obtained under the same conditions, and nothing more!" Being suspicious now, he repeats the experiment – and obtains these results.

	Filler A	Filler B
	23,200 psi.	42,950 psi.
	33,000	46,000
	37,000	47,050
Average	31,067	45,333

Now A joints are only 69% as strong as B joints. (Incidentally, standard deviations are 7100 psi. for A and 2130 psi. for B, but nobody is particularly concerned.)

Differences become apparent with the second group of tests. If he ran the experiment a third time, he could expect another set of averages.

Why the discrepancies? They arose from the combined effects of the things he thought were held constant but which weren't. Since he has not accounted for the components of variation, he cannot conclude that the calculated averages approximate the strengths of joints made with fillers A and B.

In this example, the second set of tests was run only to show that it yielded another pair of estimates. Actually, analysis of the first set would give the information needed. Knowing the precision desired, a very good estimate of the additional tests needed could be obtained.

Let's see what can be done with the original set of six tests. First, we obtain a measure of scatter (standard deviation) for the two filler alloys. The difference between the average strengths is then compared with the amount of scatter. A simple statistical calculation known as the "t" test reveals that this difference could easily have occurred by chance alone. Hence the conclusion that A joints were 75% as strong as B joints is not justified. Similar inconclusive results are obtained by applying the test to the second group. In other words, scatter is too great to justify such a fine distinction.

However, the experiment was repeated, and the data can now be combined:

	Filler A	Filler B
	40,950 psi.	42,950 psi.
	23,050	44,100
	36,000	45,650
	23,200	42,950
	33,000	46,000
	37,000	47,050
Average	32,200	44,833
Standard Deviation	7,480	1,710

Since our estimates are much better, not only can we determine that a difference exists but we can also estimate the difference.

Examination of these values leads us to suspect that the scatter in A values might be significantly greater than in B values. So we try another simple test, and find that there is less than one chance in 20 that such a large difference in scatter could have occurred by chance alone. In other words, there appear to be some inherent differences in the filler alloys.

Conclusions

1. Filler B joints are stronger than filler A joints by an average amount somewhere between 5660 and 19,610 psi.

2. Filler A joints have average strength between 24,350 and 40,050 psi.

3. Filler B joints have average strength between 43,040 and 46,600 psi.

Subsequent metallographic examination revealed that alloy B dissolved and diffused so rapidly that none of the joints tested contained any weak intermediate phases. Conversely, solution and diffusion rates in alloy A joints were marginal; intermediate phases caused weakening.

The statistical approach, therefore, has not only helped us draw more meaningful conclusions, but has also revealed an important property of one of the filler alloys. We can now construct a bar graph (Fig. 1) which will reflect the degree of uncertainty in the data.

Narrow scatter bands in the data are essential to sensitive experiments. If we expect to "find" small differences *between* groups, then the points *within* groups must agree very closely. Statistical analysis makes this concept real and quantitative. We could test with much better equipment and instruments, but then there is the danger of obtaining artificial results which may be worse than none at all.

We said earlier that our alleged constants were the sources of the scatter. It now appears that many of these so-called constants are in reality variables. These suspected variables can often be varied intentionally. Furthermore, by random testing procedures, all the "constants" can be thrown into a pot and thoroughly mixed while the suspected variables are measured and accounted for. This is termed "analysis of variance". The more "constants" we build into the experiment as controlled variables, the more variance we can account for, and the end result is more meaningful.

Returning to our relatively small problem, it is apparent that we can devise a more efficient experiment, one yielding functional relationships for any combination of independent variables in terms of strength. Estimates of experimental certainty would also be obtained. Finally, an extremely important phenomenon (and one seldom found by traditional methods) – interaction among variables – would be revealed and measured.

To realize the highest efficiency we would have to buy the large economy package. That is, the most efficient approach would give us answers to more questions than we've asked. Assuming we're willing, we proceed – and group our variables like this:

A. Dependent Variables
   1. Strength

B. Independent Variables
   1. Controlled
      a. Time
      b. Temperature
      c. Heating rate
      d. Clearance
   2. Fixed
      a. Filler alloy specification
      b. Base alloy specification
      c. Operator
      d. Equipment
   3. Random
      a. Ambient temperature
      b. Ambient humidity
      c. Order of testing
      d. Variations of chemical analysis
      e. Several dozen others

Fitting these into the experimental design, we find that less than 50 tests could yield (*a*) experimental error, (*b*) effects of any one or combination of independent variables, and (*c*) scientific measures of confidence in our results.

Of course the statistician has many, many more tricks up his sleeve. Though they may seem somewhat baffling to the neophyte, they were designed primarily to serve us. It is characteristic of people who have gained some "feel" for the statistical approach that they are elated over the tremendous possibilities and impatient with traditional experiments which by comparison seem futile. Actually, efficiency is the least of the advantages to be gained. Confidence and the ability to make important decisions in the face of ever-present uncertainty are the real advantages.

It was mentioned earlier that test results sometimes don't agree with our engineering judgment. There is nothing wrong with using our engineering judgment to make decisions so long as we remember that they are judgment decisions. However, we test when we doubt our engineering judgment. If we test, we must then be consistent and let the results dictate our decision. If engineering judgment and test results conflict, more testing is indicated. We shouldn't stop testing at this point and revert to our original judgment.

The principles suggested here are neither novel nor dramatic enough to warrant the term "technological breakthrough". The long-range results, however, could have a significant impact in the field of fusion brazing.

A Modified Phase Diagram for Stainless Steel Weld Metals

*By W. T. DeLONG**

A revised diagram for predicting the amount of ferrite in stainless steel welds is proposed. It accounts for the austenitizing effect of nitrogen in the welding rod. Predictions are closer to true ferrite content than was possible with the original Schaeffler diagram. (N8, K9; SS)

THE SCHAEFFLER constitution diagram for stainless steel weld metals (see Data Sheet, p. 100-B) † has been used widely for many years to estimate the ferrite content of weld metal. However, frequent discrepancies have been observed between values calculated from the Schaeffler diagram and those obtained from the same samples by Magne-Gage readings.

An extensive investigation was undertaken to determine the cause of these variations. A study of more than 600 undiluted weld samples of seven grades of stainless steel suggests several changes in the accepted constitution diagram for stainless steel weld metal. The proposed diagram differs from Schaeffler's in the following ways:

1. Addition of a nitrogen equivalent, which allows for the presence of the gas in all commercial stainless steels, changes the location of all ferrite lines.

2. The slope of the constant ferrite lines is increased to correct the discrepancies found between the calculated and measured ferrite in such stainless steels as Types 316 and 309.

3. Spacing between constant ferrite lines is now relatively uniform. On the Schaeffler diagram the spacing varies; it is noticeably greater at the 10% ferrite area than in the 0 to 5% or the 15 to 20% area. (The data now available do not allow the extension of the new diagram to higher percentages of ferrite, but it is obvious that the spacing between ferrite lines must decrease as the ferrite level increases.)

Test Procedures

The ferrite level of each test deposit was first calculated from its chemistry using the Schaeffler diagram, and then the Magne-Gage. Pads for Magne-Gage tests were built up on Type 304 stainless plate $\frac{3}{8} \times 1 \times 2\frac{1}{2}$ in., using stringer beads one on top of the other. A minimum of nine layers was applied. Cooling on all passes except the last was by water quenching from a dull red heat. The last pass was air cooled. Magne-Gage readings were taken on the top surface without any further finishing, avoiding the start end, because it is sometimes high in ferrite, and the crater, because it is low in ferrite. Readings made on pads which are two or three beads wide and prepared in the same manner give equal values.

*Chief Metallurgist, McKay Co., Pittsburgh.

†First published in *Metal Progress*, November 1949, p. 680-B.

Table I – Test Pad Data Based on Schaeffler Diagram

Weld Metal Type	Total No. of Pads	Average Equivalent		Average Difference*
		Cr	Ni	
308 L	103	19.9	12.0	−1.6%
347	223	20.7	12.2	−1.0
308	94	20.4	12.5	−1.2
308 Mo	38	22.1	13.7	−0.1
316	22	21.9	15.9	+5.1
316 L	101	21.9	15.1	+3.1
309	74	24.6	17.2	+2.8

*Difference between percent ferrite measured by Magne-Gage and calculated from Schaeffler diagram.

Readings made on machined surfaces or on cross sections are not as dependable because ferrite orientation and concentration varies. (Other investigators have shown that the size, shape, and orientation of the magnetic phase can affect readings. Our use of the Magne-Gage depends on the elimination of these variables by establishing constant and reproducible test locations and conditions.) We used the Magne-Gage by allowing the No. 3 magnet to contact the pad, and measuring the dial reading (torque) necessary to pull the magnet off the surface. A calibration curve correlating the amount of ferrite with the Magne-Gage reading was developed from both metallographic studies of weld metal and the use of powdered metal compacts containing iron and copper.

The average difference between the calculated ferrite value and the measured value in the weld specimens is given in Table I. A positive number indicates that the measured ferrite level was higher than the ferrite level as calculated on the Schaeffler diagram.

The data in Table I show that Types 316, 309, and related compositions, which have higher chromium and nickel equivalents than Types 308 and 347, contain appreciably more ferrite than the Schaeffler diagram predicts. Observations made during the investigation suggest that a factor for nitrogen should be added to the conventional diagram to correct this discrepancy. It was learned early in the study that the pads which contained appreciably less ferrite than expected were made from relatively high nitrogen heats. For this reason Types 308, 347, and 308 L averaged 1.0 to 1.6% less ferrite than was calculated by the Schaeffler diagram. The remaining heats with normal nitrogen showed good agreement between calculated and measured ferrite, far better in fact than the ±4% claimed by Schaeffler.* This observation has been confirmed by others who have been using his diagram to calculate ferrite in Types 347 and 308 L, and is a tribute to his excellent work in this field.

The Nickel Equivalent for Nitrogen

Nitrogen is a strong austenitizer. It is reported that 0.10% of the gas is equivalent in austenitizing power to 3 to 4% nickel in highly alloyed chromium-nickel steels. To establish a nitrogen factor for the revised Schaeffler diagram, a study was made of 27 weld pads of Types 308, 308 L and 347 in which the nitrogen content was high (over 0.115%). The amount of ferrite to be expected was predicted from the original Schaeffler diagram for each pad. Nitrogen content of each was determined and the actual amount of ferrite present – always less than that predicted in these high-nitrogen alloys – was measured by the Magne-Gage. The difference between the expected ferrite and the actual ferrite points out the austenitizing ability of nitrogen.

The ferrite equivalent to a given amount of nitrogen can be obtained by dividing the difference between the actual ferrite and expected ferrite by the percentage nitrogen in each pad in excess of that found in commercial stainless (0.055%). For 24 of the pads, this factor averaged 0.6% ferrite per 0.01% nitrogen. On the new diagram which will be described later, 0.6% ferrite is equivalent to 0.3% nickel. Therefore the nickel equivalent of nitrogen was set at 30 times the percentage nitrogen.†

Nitrogen analyses were run on a number of the other weld pads to supplement the data from the high-nitrogen heats. New nickel equivalents were calculated for each pad in which a nitrogen content was known and the

*As a matter of fact, heats with normal nitrogen will plot out almost identically on the Schaeffler and DeLong diagrams.

†Editor's Note: The nitrogen factor of 30 can be supported by numerous literature references. Schaeffler in 1948 prepared a report (unpublished) on "Nitrogen as an Austenite-Forming Element" (Arcos research files, Experiment 598), which concludes: "A literature survey has been made to investigate the potency of nitrogen as an austenite-forming element. It is proposed that nitrogen has a potency factor of 30; that is, 0.10% nitrogen is able to replace about 3% nickel."

revised diagram was constructed. (See bottom of Data Sheet p. 100-B.) Special pads were made to bridge the gaps between Types 308, 309 and 316. Two heats of 308 and 309 and one heat of 316 L were included. A series of coatings was extruded on core wires from these heats with additions to decrease the chromium and nickel in one set, and to increase the chromium and nickel in another. The revised diagram is limited to the chemical composition range of the weld metal types studied. The chromium equivalent is the same as for the Schaeffler diagram; the new nickel equivalent is now equal to % Ni plus 30 × % C plus 30 × % N plus 0.5 × % Mn.

Calculated and Measured Ferrite Comparison

It was then possible to compare the spread between measured and calculated ferrite for the pads available, making this comparison first for the Schaeffler diagram, and then for the new tribution curve included in Fig. 1, the results are in reasonable agreement both in shape and spread of values. The spread in most instances does not exceed ± 2% ferrite – a figure which could be predicted from the known variations in Magne-Gage readings and chemistry. Second, the discrepancies found between measured and calculated ferrite in the Schaeffler diagram at higher chromium and nickel equivalents, as in Types 316, 317 and 309, were corrected.

There were a few pads in which measured ferrite exceeded the calculated value by more than 2%. In general, these were found to be high-nitrogen heats, where the nitrogen factor of 30 evidently overcompensates for the effect of the high nitrogen contents.

Effect of Other Factors

Electrode size and coating type were found to have little influence on the ferrite content of the deposit. We can, however, draw some

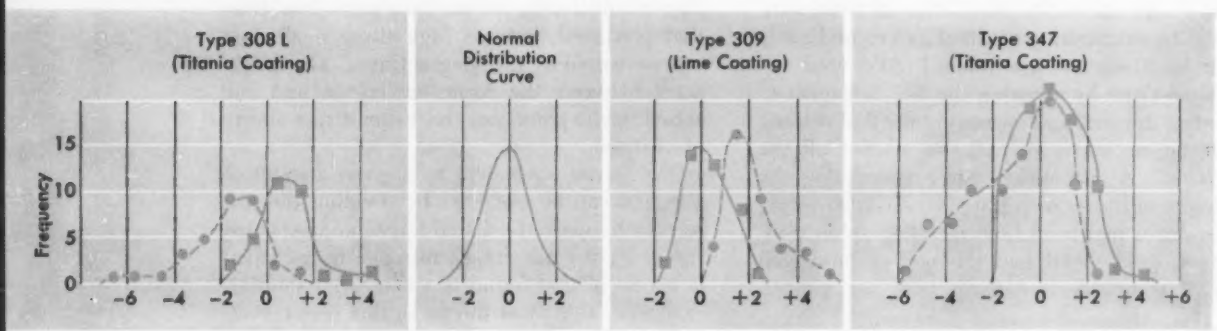


Fig. 1 – Distribution Curves Show the Effectiveness of the Revised Diagram in Reducing the Percent Deviation of the Predicted Amount of Ferrite From That Which Is Actually Present, Shown Here as the Abscissa. Normal distribution curve shows deviations attributed to welding and analytical techniques

diagram. Figure 1, which gives sample distribution curves, shows how the new nickel equivalent has improved the ability of the diagram to predict accurately the amount of ferrite.

Figure 1 also includes, for reference, a normal distribution curve incorporating deviations in measured ferrite that might be attributed to welding procedure and differences between the true and reported chemistry of the deposit.

The distribution curves demonstrate two major points. First, the introduction of a nitrogen factor in the nickel equivalent has effectively decreased the deviation of the ferrite predictions from the measured value in high-nitrogen, low-ferrite pads. When the distribution curves are compared with the normal distentative conclusions on the minor effects of these variables. A rather unusual and unexpected observation was that the titania-type coatings tend to give welds which average approximately 1% higher in ferrite for a given chemistry than the lime coatings. This is not a particular advantage or disadvantage because ferrite at a desirable level is obtainable with either coating by proper control of chemistry. Electrode size had less influence on ferrite than coatings. In general, a greater number of welds which contained less ferrite than predicted were made from small diameter electrodes than from the larger sizes. This trend was appreciably more pronounced in the lime coatings than in the titania coatings.

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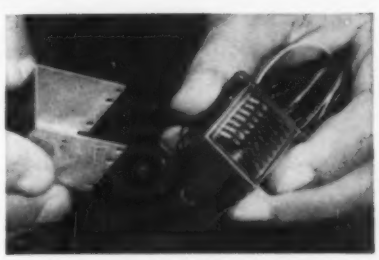

Tiny magnetic head of tape recorder has Mumetal shields to trap magnetic interference, help Davies Lab. Division of Minneapolis-Honeywell pack much in little space. Nickel-chrome plating or cover adds durability, corrosion resistance, and attractive appearance.

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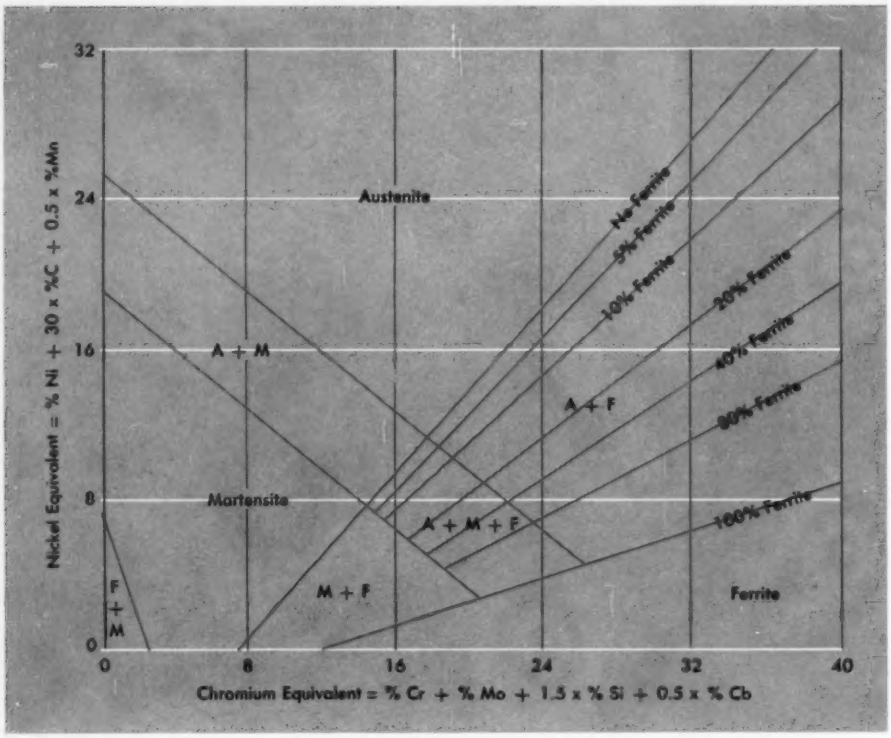
Circle 514 on Page 48-A

Constitution Diagram for Stainless Steel Weld Metal

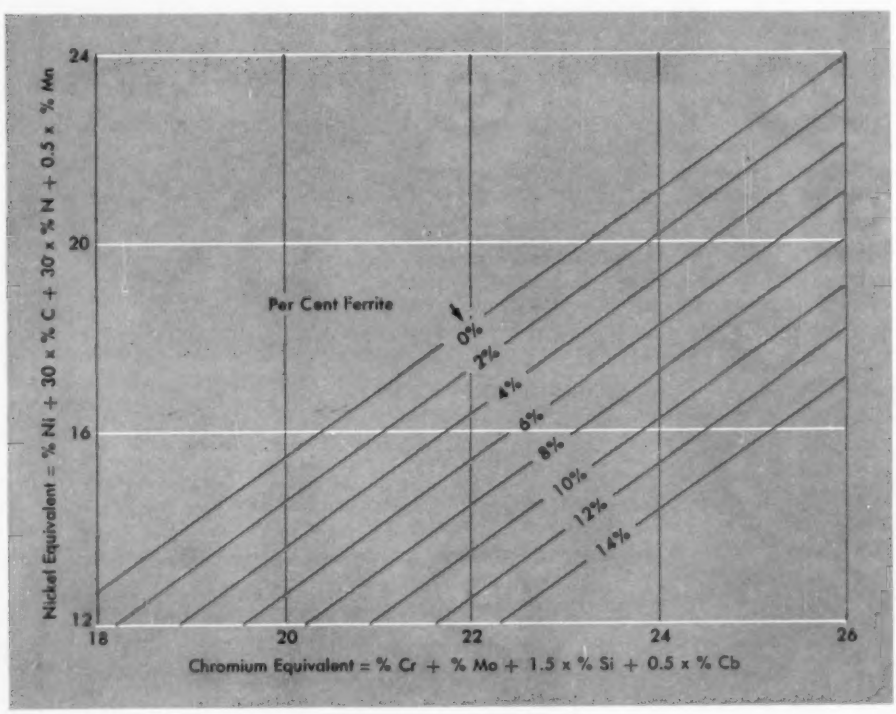
By ANTON L. SCHAEFFLER



Originally published as a Metal Progress *Data Sheet (November 1949, p. 680-B) and developed by Mr. Schaeffler while he was employed by Arcos Corp., Philadelphia. (Mr. Schaeffler is now with Allis-Chalmers Mfg. Co., Milwaukee.) The diagram predicts microstructures obtained in stainless steel weld deposits from electrodes of known composition. Schaeffler's diagram makes a blanket allowance for nitrogen, which is known to vary with chromium according to steelmaking practice. The diagram incorporates nitrogen values of 0.05 for low-chromium alloys, through 0.10 for the high-chromium steels*

Revised Section of Schaeffler Constitution Diagram

By W. T. DeLONG



The addition of a factor for nitrogen in the nickel equivalent improves the accuracy of the diagram in predicting the amount of ferrite present in a stainless steel weld. At normal nitrogen levels this diagram is almost identical with Schaeffler's

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Circle 587 on Page 49-A

How Boron Affects Corrosion of Type 304 Stainless

*By J. W. FARRELL and P. C. ROSENTHAL**

Although boron improves the corrosion resistance of wrought Type 304 stainless, the protection it gives is not outstanding by present standards. (R2h, 2-60; SS, *B*)

PAST INVESTIGATIONS have found that small additions of boron reduce the susceptibility of cast Type 304 stainless steel to intergranular attack. Work reported here was undertaken to determine whether similar behavior could be expected in wrought Type 304. Although helpful in reducing sensitization, boron did not provide complete or satisfactory protection. All heats with boron added (up to 0.0063%) were attacked at a rate greater than 0.002 in. penetration per month in boiling nitric acid (65%). As exposure time was increased, rate of attack was accelerated.

Test Procedure

Resistance to sensitization in the range from 1000 to 1400° F. for four heats of wrought Type 304 stainless steel containing different amounts of boron was evaluated (Table I). This was done by measuring the rate of intergranular attack in boiling 65% nitric acid (A.S.T.M. specification A 262-44T). Seven specimens were tested from each heat. Six were sensitized 2 hr. at 1000, 1100, 1200, 1300, 1400 and 1500° F. after solution heat treating them for 1¾ hr. at 1975° F. and water quenching. The seventh specimen was solution treated and quenched but not sensitized. Tests were conducted in boiling nitric acid for 48-hr. periods.

Boron Improves Resistance to Attack

All the heats exhibited intergranular corrosion in the sensitized condition. The rate at which corrosion occurred varied substantially with the boron content. The increase in corrosion rate as a function of exposure time in nitric acid is shown in Fig. 1. Only data from heats A and D are plotted. They represent the maximum and minimum amount of intergranular attack measured for all heats. The others exhibited similar behavior with results lying between these two extremes.

Mechanism

Simcoe, Elsea and Manning ("Study of the Effect of Boron on the Decomposition of Austenite", *Transactions*, A.I.M.E., Vol. 7, January 1955, p. 193), in their work on boron and its effect on the decomposition of austenite, state that boron increases hardenability by decreasing the nucleation rate of ferrite and bainite. They point out that the boron atom is an "outlaw" in solid solution in iron; the size ratio of the boron atom to the iron atom, 0.75, is too large to permit it to be interstitial and too small for it to be substitutional. Further, they postulate that the first boron atoms introduced enter sites near lattice imperfections where the atomic spacing is about 25% smaller than that of a perfect iron lattice, thereby lowering the energy peaks in these areas. Boron atoms occupy positions at the grain boundaries (one of the most

*Mr. Farrell is a metallurgical engineer in the Technical Department, Product Development Laboratory, Union Carbide Metals Co., Niagara Falls, N.Y. Professor Rosenthal is chairman of the Department of Mining and Metallurgy, University of Wisconsin, Madison.

favorable sites) and at other lattice imperfections until all sites are filled.

When this point is reached, at about 0.0005% B, any additional boron atoms introduced are forced into less desirable locations, resulting in either increased strain energy at the grain boundaries or grain-boundary precipitation of a boron-rich phase. The net result is a loss of hardenability with increasing boron contents beyond the optimum value. Thus, boron up to about 0.0005% will increase hardenability, but amounts in excess of this result in reversal of the boron effect.

Table I – Composition of Type 304 Test Heats

Composition	Heat Identification			
	A	B	C	D
C	0.076%	0.073%	0.069%	0.071%
Cr	18.43	18.43	18.83	18.69
Ni	9.88	9.19	9.15	9.07
Mn	1.59	1.59	1.60	1.58
P	0.011	0.011	0.007	0.012
S	0.017	0.013	0.011	0.013
Si	0.54	0.47	0.31	0.49
B	none	0.0007	0.0037	0.0063

It is postulated that at least to 0.0037% B the mechanism described above also explains the behavior of boron in reducing the rate of intergranular attack of the stainless steels. This is supported by the curves in Fig. 2 which is a plot of the average corrosion rate for five boiling periods as a function of the boron content for specimens sensitized at three temperatures. From no boron to 0.0007% B, the rate of intergranular attack decreases markedly. Between 0.0007 and 0.0037 B, the rate of intergranular attack increases again, presumably due to increased strain at the grain boundaries or grain-boundary precipitation of a boron-rich phase when boron contents are greater than the optimum. It is believed that due to the high carbon content and inherent susceptibility to carbide precipitation of these steels, the grain-boundary precipitate is not boron-rich, but rather a carbon-rich phase which precipitates by a strain-relieving mechanism thereby resulting in a higher rate of intergranular attack.

Beyond 0.0037% B, the curves fall rapidly again. This second decrease in the rate of attack cannot be explained in terms of reduction of grain-boundary energy because the optimum boron content (0.0005%) has been exceeded. However, metallographic studies show that, for identical thermal histories, the amount of general precipitation within the grains increases as the boron content increases. This same phenomenon occurs regardless of the sensitizing temperature, although to a lesser degree at lower temperatures. It is suggested that above 0.0037% B the general precipitation is great enough to exert an influence on the intergranular attack by either decreasing the amount of precipitate available for the grain boundaries, or by replacing the original carbide precipitate with a boron-rich precipitate more immune to intergranular attack.

The results of exposing sensitized (2 hr. at 1250° F.) and unsensitized specimens to boiling acidified copper

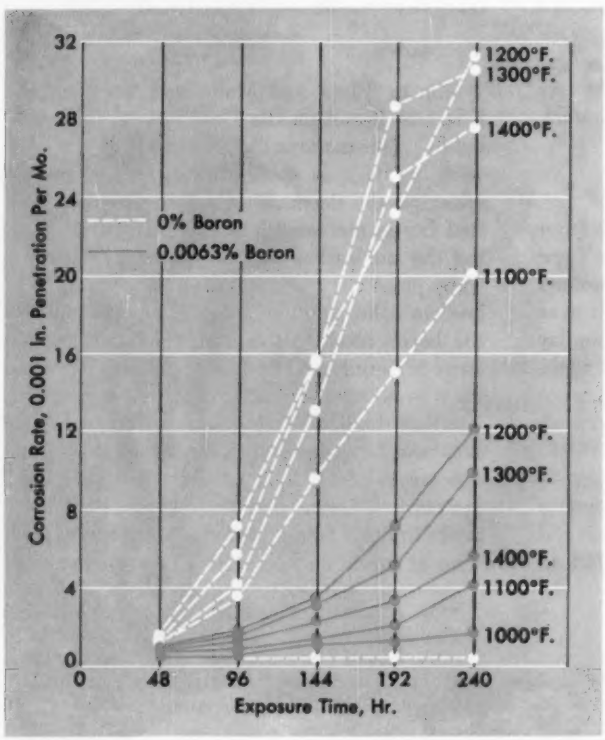


Fig. 1 – Effect of 0.0063% B and Exposure Time in Boiling Nitric Acid on Corrosion Rate of Type 304 Stainless Steel

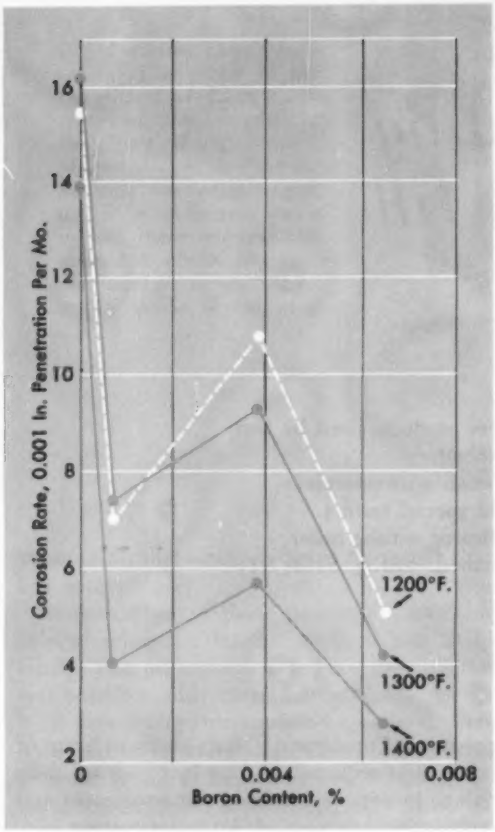


Fig. 2 – Effect of Boron Content and Sensitizing Temperature on the Corrosion Rate of Type 304 Stainless Steel. Specimens were exposed for 240 hr. in boiling 65% nitric acid

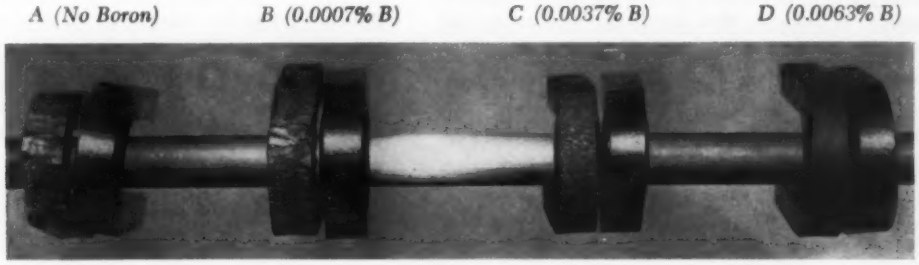
sulphate solution for 72 hr. (Strauss test) and subsequently bending them 180° is shown in Fig. 3. These results do not follow the same pattern as the Huey test results shown in Fig. 2 in that the low corrosion rate of the 0.0007% boron alloy is not duplicated. Rather, the sensitivity to attack decreases progressively with boron content. The initial decrease in corrosion rate with a boron addition in the vicinity of 0.0005 to 0.001% is believed to be more typical, however, inasmuch as it was also experienced with cast steels exposed to the Strauss test in a previous investigation. The failure of the 0.0007% boron steel to react as favorably in the Strauss tests as in the Huey test is not understood. The only apparent differences between the conditions for the Huey and Strauss tests were in the geometry of the test samples and the use of 1250° F. for the sensitizing temperature for the Strauss tests.

Protection Not Complete

Although boron was helpful in reducing intergranular attack, by no means did it provide a complete or satisfactory type of immunity. H. A. Pray (Corrosion Handbook, edited by H. H. Uhlig, John Wiley and Sons, 1948, p. 1016) points out that a uniform corrosion rate from one 48-hr. boiling period to the next is desirable, but corrosion rates that increase from one period to the next indicate undesirable performance. As shown in Fig. 1 increases in corrosion rate from period to period of the specimens containing boron (Heat D) are much less than those with no boron. However, samples from Heat D are more subject to an accelerating type of attack (indicated by the continually changing slope of the curve) than the normal Type 304 steel. Of the samples which contained no boron or 0.0063% boron only those sensitized at 1000° F. corroded less than 0.002 in. penetration per month, a commonly used criterion in the boiling nitric acid test.*

*"Corrosion Resistance and Mechanical Properties of Low-Carbon Austenitic Stainless Steels", *Symposium on Evaluation Tests for Stainless Steels*, A.S.T.M. Special Technical Publication No. 93, A.S.T.M., 1950, p. 60.

Fig. 3 – Results of 180° Bend Tests on Heats A, B, C, and D for Sensitized (Specimens at Left of Each Pair) and Unsensitized Type 304 Stainless. Bars were exposed 72 hr. in boiling acidified copper sulphate (Strauss test). Note that bend tests do not follow same pattern as Huey tests (Fig. 2)



Nondestructive Testing in a Steel Mill

*By W. A. BLACK**

A nondestructive method for testing steel products must be fast, cheap, automatic and, above all, discriminatory. Since little equipment of this sort is available commercially, it is often necessary to design and build special testers. Three unique devices, a seam depth indicator, a tube tester, and a portable ultrasonic unit, are described. (S13g, S13h; ST)

THROUGH NONDESTRUCTIVE TESTING, each piece of material in a lot can be tested for quality. This mere fact has opened important new and broad fields for inspection processes which the exacting demands of modern design have made necessary. Today, hundreds of thousands of parts must be produced with a degree of freedom from flaws that would have been impossible 20 years ago. Much of the credit for this accomplishment can be attributed to nondestructive testing methods. They have made it practical to test each and every item involved, and to locate defects on both materials and finished products.

In steel production, as in other fields, inspection has proved to be an effective weapon in the battle to keep costs within bounds. It also helps detect and eliminate causes of accidents. It has even compensated (partially) for steadily rising prices of labor, equipment, and raw materials. However, the steelman faces special problems in applying nondestructive testing techniques.

The steel industry deals, in general, with vast quantities of product having a low cost per unit. Consequently, tests costly in terms of equipment required or time involved are difficult to justify. Specialized test equipment and techniques are needed to make testing economically feasible.

To put it simply, in testing semifinished metals, such as steel, a nondestructive method must be fast, cheap, automatic and, above all, highly discriminatory to be useful. The last specification is indeed a vital one, because unjustifiable rejection of a product that the customer could use can quickly make the entire operation unprofitable.

Republic Designs Its Own

The need for both automatic operation and accurate discrimination impelled Republic Steel Corp. to design and build some of its own nondestructive testing equipment. One such piece of equipment, the seam depth indicator, is shown in Fig. 1. When its development was begun (about 12 years ago), the only "tool" generally used by the industry to determine seam or crack depth was a flashlight and a pair of eyes. Occasionally, this type of examination was supplemented by the use of magnetic powder in its various forms. The magnetic powder methods, while helping greatly in the mere *detection* of seams, are of questionable

*Assistant Director of Research, Republic Steel Corp., Cleveland. This article was condensed from a talk given before a meeting of the Society for Nondestructive Testing, Los Angeles, March 1959.

Fig. 1 – Seam Depth Indicator. The probe in the foreground induces currents in the surface of the part being tested. Magnitude of the current depends on seam depth which is indicated on a meter. Since movement is needed to obtain readings, the workpiece is rotated or the probe is oscillated

value in distinguishing between deep and shallow seams.*

Since neither of these techniques was considered adequate, another method had to be tried. The principle selected for investigation was based on eddy current induction.

In developing this equipment, several problems had to be overcome. One of them arose because harmless structural and metallurgical deviations changed conductivity of the material enough to affect the magnitude of the eddy currents; this change in magnitude registered on the instrument. Fortunately, these deviations were gradual as contrasted with the sudden sharp deviation resulting from a crack. To avoid indicating such changes, the circuit was designed to be insensitive to slow, gradual variations, reacting only to rapid changes occurring when cracks and seams were crossed.

Undesired signals also occurred when the search coil was removed from the work surface. In early models, a bounce caused by a slight surface imperfection or the act of lifting the coil off the surface caused the same type of signal as did a defect. Since semifinished material usually has a fairly rough surface, this type of signal could be expected frequently. Consequently, the "lift-off" signal had to be eliminated before the instrument could be used in any automatic inspection system. Fortunately, the electrical differences between the genuine and spurious defect signals were great enough so that a circuit could be developed to screen out the unwanted signals.

This instrument has one inherent shortcoming. In its present form, it will not detect subsurface seams. Thus, if any portion of the seam is short-circuited by conducting material, the depth is not registered correctly. This means that the instrument is limited to seams which are either open or filled with nonconducting material. Even with this limitation, however, the instrument is extremely useful because most cracks or seams in semifinished stock are filled with nonconducting iron oxide.

The manual instrument has also been useful in preventive maintenance work. Maintenance men often need to know the depth of a crack located by magnetic powder methods. Is it dangerously deep or harmlessly shallow? Our device gives the answer quickly and easily.

*Perhaps the basis for interest in discriminating between deep and shallow seams should be explained. Steelmen spend many millions of dollars every year to remove cracks and seams from the surface of semifinished billets and bars. They would like to reduce the expenditure. Of course, they would prefer to produce these products without imperfections, but the solution to this problem seems to be a long way off. In the meantime, each batch of billets produced is likely to contain seams, and thus require some surface conditioning. There are three possibilities. The seam may be shallow enough to be removed in rolling or by the customer's normal machining practice. If this is the situation, the seam is not objectionable. Next, it may be deeper but still shallow enough to be successfully removed by chipping, grinding or scarfing. Third, it may be so deep that the material is useless for its intended purpose and must be scrapped.

Thus the problem is to determine quickly and economically the depth of the crack or seam to make sure that conditioning labor is not wasted and that all seams that must be removed are properly identified.

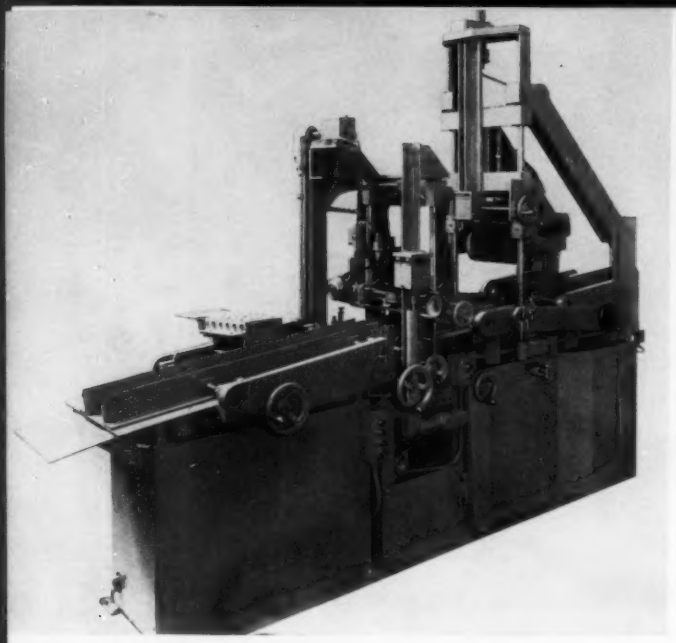


Fig. 2 – Automatic Coupling Inspector. Coupling blanks with deep seams are lifted on a small elevator and dumped into a reject bin, while acceptable couplings roll down a conveyer. Though no operator is needed, this machine does over ten times the work of one man with a manual seam detector

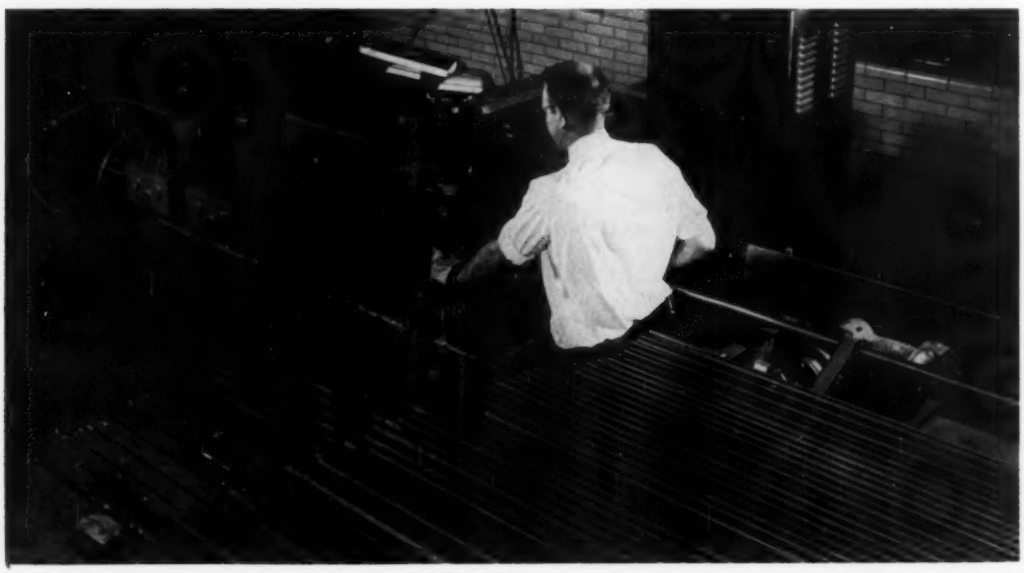
Early in its history, the seam depth indicator was used to inspect pipe couplings. In these, shallow seams usually are not a cause for rejection, but deep seams definitely are. The initial work, which started nine years ago, was all done with manual instruments, similar to that shown in Fig. 1. Several years ago, two completely automatic machines were put into service. (A third is under construction.) One of these is shown in Fig. 2. Recently an automatic billet inspector was installed which employs the same principles as the indicator. It will be used to inspect billets 3 to 12 in. square.

Inspecting Tubes With the "Farrowtest"

In 1929 it was decided to develop a device to test tubes nondestructively. Ten years later, the machine was operating successfully in production. Since the key man in the development program was the late Cecil Farrow, the test was officially named Farrowtest in his honor. For the last 20 years, this test has been in continuous use on over 300 million ft. of small tubing, both magnetic and nonmagnetic. It is now being applied in other plants to pipe of large diameter.

The basic principle of the Farrowtest is, as with the seam depth indicator, electromagnetic induction. A vital difference is that the Farrowtest circuit is sensitive to defects anywhere in the tube wall, even when there is no surface indication. When a defect passes, the induced currents are changed by its presence. This

Fig. 3 – Entry End of Farrowtester. A circumferential current is induced in the tube as it passes through a group of coaxial coils. Changes in that current appear in the output of a detector coil. This test can be adjusted over a wide range of sensitivities from low (for mechanical tubing) to extremely high (for atomic energy applications)



change can be used to stop the tube in its passage through the tester, operate a paint spray, or operate any other device for locating the defect that might be desired.

A distinguishing feature of most testing of magnetic tubing is the use of the saturating magnetic field. All of the a-c. coils which are used to generate currents are surrounded by a large d-c. coil which magnetically saturates the tube. This powerful magnetic field reduces the effect of the harmless variables usually present, such as changes in grain structure, variation in stresses, and other metallurgical conditions. It does not, however, reduce the effect of harmful discontinuities.

The Farrowtest (see Fig. 3) is, to date, the only nondestructive test developed for any kind of tubing which can be set up on an adjustable calibrated basis. It can be depended upon to detect all defects above a specified minimum size, a feat that it has been doing for almost 20 years.

Standardized calibration tubes are provided so that the machines can be adjusted to the correct level of sensitivity. With the help of these standards, all machines can be made to operate in the same way. Thus, a tube or a batch of tubing tested at different times and on different Farrowtesters gives identical signals. Rejection is mechanical and independent of the operator's observation, judgment, or opinion.

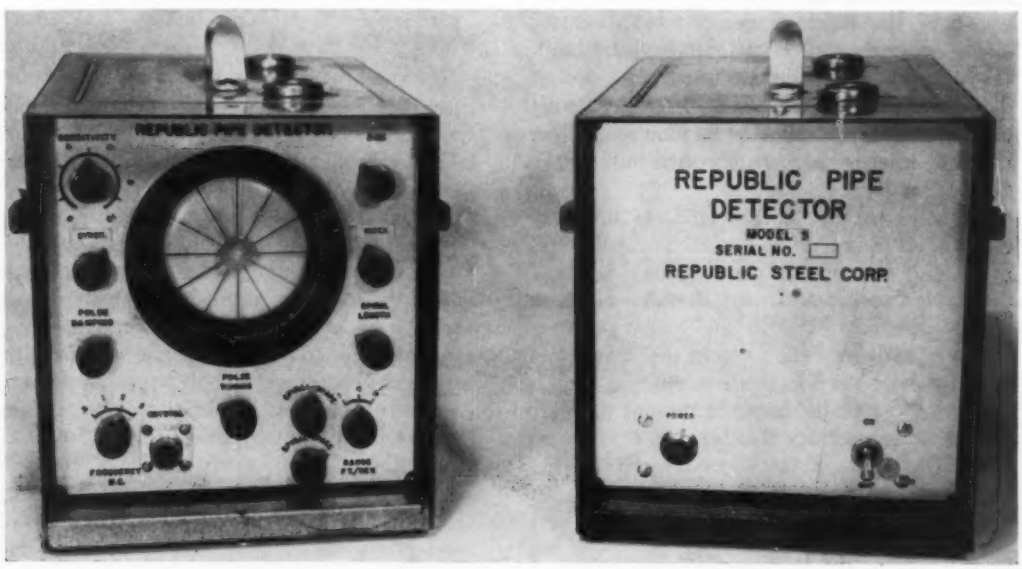
Fig. 4 – Ultrasonic Tester Built and Used by Republic Steel. Each section, the indicator on the left and the power supply on the right, weighs but 22 lb. Furthermore, only the indicator need be carried to the part to be tested; the power supply can be anywhere within 30 ft.

Ultrasonic Testing Locates Defects

Since 1945, the ultrasonic test has been used to detect minute internal discontinuities in millions of tons of steel. However, exact calibration is still the greatest handicap in this test. No one has yet developed a technique that can be relied upon to yield adequately reproducible results regardless of the instrument used and the steel being tested. Though progress is being made, a great deal of work is still needed. In the meantime, however, ultrasonic testing continues to be an extremely valuable method of controlling quality in steel products, and in reducing maintenance costs by detecting incipient failures in steel parts.

Commercial instruments are so bulky and so heavy that transportation is a major problem, particularly in preventive maintenance work. This fact is the basis for a personal discovery, Black's Law of Human Reluctance: *The degree of use to which a testing instrument is put by a maintenance man is in inverse ratio to its size, weight, and ease of interpretation!* This being an immutable law as far as human nature is concerned, the only solution is to lighten the equipment.

The first ultrasonic test instrument commercially available weighed about 300 lb. It



occupied almost as much space as a small desk, and was just about as portable. Obviously, no machine this large could be used to any appreciable degree in maintenance work.

As time went on, commercial ultrasonic instruments were reduced in size and weight. Sperry's portable Reflectoscope and the Curtiss-Wright Echoscope are two typical examples of lighter equipment. While these instruments represent progress, they are still too heavy for one man to handle easily. Figure 4 illustrates a smaller instrument devised at Republic's Electromechanical Research Center. When using it, the operator needs to carry only the 22-lb. indicator to the work. It is the unit on the left, and is about $7\frac{1}{2} \times 8 \times 14$ in. The power supply on the right is also required but it can be located anywhere within a 30-ft. radius of the detector unit. Thus, if the maintenance man wants to check on the soundness of a shaft or an axle up on a crane, he usually needs to carry only the indicator unit. Even if the entire instrument is needed, it is not much of a burden. The power supply, housed in a case identical with that of the indicator unit, also weighs 22 lb.

This instrument will do everything commercial instruments will do, but also has other important advantages. For instance, unlike most commercial instruments, it uses a spiral trace on the oscilloscope. Because of this, lengths representing distances up to 48 ft. are readily displayed on a small 3-in. tube.

The spiral trace can provide a spiral line which may be as long as 30 in. to represent the length of the article under test. This 30-in. length contrasts with a 4½-in. line on the available commercial instruments. It is obvious that the observer will be able to locate a defect more accurately on a line 30 in. long than when the same information is compressed into a trace 4½ in. long.

Reduction in size and weight has been accomplished by use of the small 3-in. tube and by careful selection of components. Some of the latter are a fraction of the size of those commonly used.

It may surprise some to learn that transistors have not been used in this equipment. This is because those available at the present time are not stable enough for this type of equipment. When transistors of the necessary stability become available, the size of the ultrasonic tester will be reduced still further.

Spring bars are used to activate large vibrator screens in ore processing plants. Several of these giant bars are tuned to the natural period of the screen driving mechanism, and the resonant action of the bars reinforces the vibration of the screen. When any bar develops fatigue defects, screen efficiency drops noticeably.

Prior to ultrasonic inspection, defective bars could be detected only by dismantling the whole assembly, and cleaning, examining and testing bars individually. Under these circumstances, a cracked bar could cause many lost production hours. Now, with the ultrasonic tester, the offending bar can be located in a few minutes. No dismantling is required, and the defective bar is replaced with a minimum of downtime.

Another interesting application: Tightness of the fit of bearing sleeves on diesel locomotive axles can be examined ultrasonically. A satisfactory sleeve fit sets up stresses in the axle which can be registered ultrasonically. If the correct stress pattern is not pictured on the screen, the sleeve is ruptured. This might be called an indirect method of testing since the axle, not the defective sleeve, is tested.

One unique and difficult maintenance problem involved the checking of ½-in. diameter rivets holding the blades on a blast furnace blower. In this instance, some defective rivets had been discovered, and a program was being promoted to replace all of the rivets. However, these rivets were successfully examined with the tester shown in Fig. 4. The few defective ones were accurately isolated, even though some were only 5/16 in. in length.

Summation

These three examples, the seam depth indicator, the Farrowtest, and the small ultrasonic tester, indicate how one steel producer has tried to apply nondestructive testing. These items, however, serve but a small fraction of the needs of the industry. Specialists in nondestructive testing have naturally concentrated their attention on the high-risk applications in which the user can afford elaborate testing in the interests of safety. Though there has been some attention to the needs of the steel industry for highly discriminatory, high-speed automatic equipment, progress has been meager to date. Perhaps the future will bring increased research along these lines. Such work is certainly needed, and would surely be welcomed by those who are concerned with inspection in steel production.

Grain Size in High-Alloy Hot Work Toolsteels

*By R. F. HARVEY**

An isothermal method for outlining grains enables investigation of composition and heat treatment effects on high-alloy toolsteels. Tungsten inhibits grain growth, and rehardening treatments result in duplex structures. (M27c; TS)

THE TOOLSTEELS containing tungsten or molybdenum have the highest red hardness of the hot work steels. They need this to withstand high working temperatures encountered in dies for extrusion, die casting and forging. Grain size ratings offer a simple but quantitative means for evaluating and controlling the structure and properties of these toolsteels. However, this method has never been used extensively because grain boundaries are difficult to outline by the available techniques.

Delineating Methods

Three techniques have been employed to outline grain boundaries in hot work toolsteels. Of these, the fracture grain size method can mislead because intergranular fractures are not always obtained, and the second method, oxidation, is difficult to apply. The most practical method is the isothermal technique used by Payson and Nehrenburg† for several tungsten and chromium-base hot work steels. Essentially, the specimen is quenched below the lower critical temperature, and held until pearlite outlines the grain boundaries. We have used this method to evaluate the eight hot work steels whose analyses are listed in Table I.

After preheating at 1400° F., disks ½ in. thick were austenitized at 1950, 2050, 2150, 2250 and 2350° F. A holding time of 20 min. was used for every temperature but 2350° F. For this, a holding time of 10 min. was used. To delineate the grain boundaries, the specimens were transferred to another furnace at 1400° F. where they were held for 8 min. and then

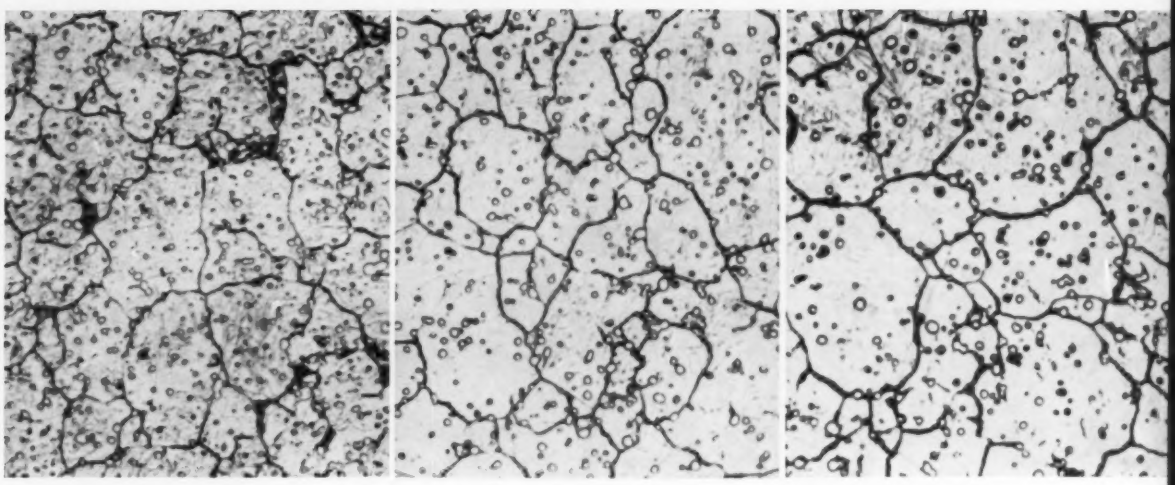
Table I — Composition* of High-Alloy Hot Work Steels

CODE	C	W	CR	V	MO	CO	NI
1	0.34	9.88	3.49	0.57	0.38	0.50	0.16
2	0.36	10.52	3.30	0.40	0.56	0.25	0.16
3	0.29	10.29	3.03	0.24	0.58	0.51	0.78
4	0.52	12.59	3.40	0.59	0.73	0.37	0.15
5	0.32	12.13	2.58	0.43	0.45	3.63	0.23
6	0.49	15.60	2.98	0.52	0.57	0.29	0.17
7	0.42	4.08	4.12	1.96	0.70	3.80	0.10
8	0.43	1.40	3.72	0.72	5.62	0.09	0.17

*All steels have 0.17 to 0.30 Mn, 0.14 to 0.33 Si, 0.013 to 0.022 P, 0.006 to 0.0125 S.

*Research Metallurgist, Braeburn Alloy Steel Corp., Braeburn, Pa.

†"The Metallography and Properties of High-Alloy Hot Work Steels", by P. Payson and A. E. Nehrenburg, *Yearbook*, American Iron and Steel Institute, 1948, p. 540.



1950° F.
15.6

2050° F.
11.7

2150° F.
9.9

quenched in water. In another series of tests, the effect of holding times for specimens austenitized at 2050 and 2150° F. was investigated.

Hardening Temperature

The effect of austenitizing temperature on the eight compositions is given in Table II. Figure 1 also illustrates the variation in grain size of steel H21 (Code 1) when austenitized at 1950, 2050, 2150, 2250 and 2350° F., and isothermally treated. It should be noted that conventional quenching – which usually consists of quenching into oil, removing hot on loss of color and air cooling to room temperature – does not reveal these boundaries.

Effect of Tungsten

Though the data are not conclusive because other elements vary widely in the eight steels tested, it is apparent that grain refinement occurs when tungsten is increased. Composition 6, the toolsteel with the largest amount of tungsten (15.6%), had the smallest grain size at all temperatures tested. The molybdenum-base composition (8) was considerably coarser than similar alloys with an equivalent amount of tungsten, particularly when austenitized above 2150° F.

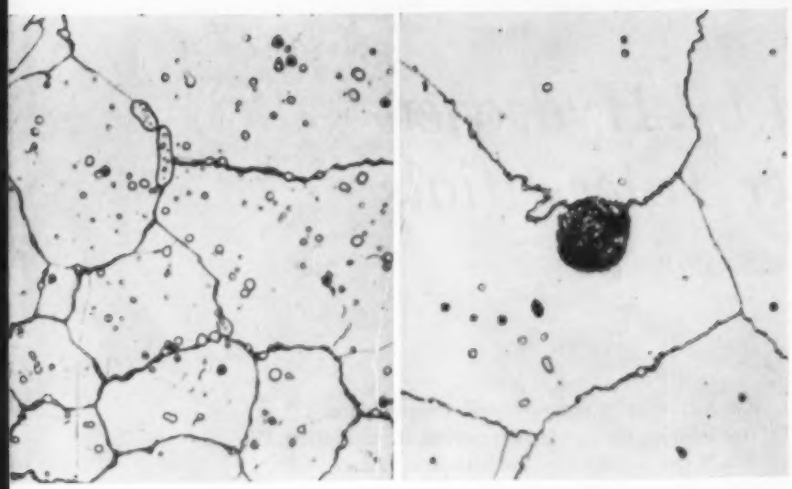
Austenitizing Time

The effect of hardening time on grain growth was investigated with the results shown in the right-hand columns of Table II. At 2150° F. all compositions coarsened continuously with increasing time. Composition 6 again had the finest grain size, and Composition 7 had the coarsest grain size for long hardening times.

Since hot work steels may be occasionally reheated to hardening temperatures, we also decided to make a limited investigation concerning

Table II – Effect of Austenitizing Temperature and Time on Grain Size

	Temperature					Time at 2150° F.		
Code	1950° F.	2050° F.	2150° F.	2250° F.	2350° F.	20 Min.	1 Hr.	6 Hr.
1	15.6	11.7	9.9	7.2	4.3	9.9	9.7	9.2
2	—	10.4	9.7	8.8	5.3	9.7	9.4	8.8
3	—	10.2	10.1	9.0	3.2	10.1	8.0	7.6
4	—	13.4	11.4	10.4	6.9	11.4	10.7	10.2
5	—	9.7	9.5	7.9	4.5	9.5	8.8	8.6
6	—	18.1	17.5	14.6	11.1	17.5	12.0	11.3
7	—	11.6	5.5	3.1	1.5	5.5	4.0	1.8
8	11.1	10.2	5.0	3.8	2.8	5.0	4.2	2.4



2250° F.
7.2

2350° F.
4.3

Fig. 1 – Variation of Grain Size With Temperature. These specimens of Composition 1 (Steel H 21) have been etched in 5% nital and photographed at 1000 ×

the grain coarsening characteristics of composition 1 (H21) on rehardening without an intermediate anneal. Initial hardening temperatures of 1950, 2050, 2150, 2250 and 2350° F. were used, and rehardening was also done at these five temperatures. This made a total of 25 rehardening treatments investigated.

After the second hardening treatment, the isothermal quench mentioned previously was used to outline the grain boundaries. The results of double hardening are shown graphically in Fig. 2.

On rehardening without an intermediate anneal, very coarse grains were encountered on many of the rehardened specimens. A duplex grain structure was also observed on rehardening at 2150° F. or higher. Though other investigators have reported that subgrains are needed for discontinuous coarsening in high speed steels, subgrains were not encountered on any of our rehardened specimens.

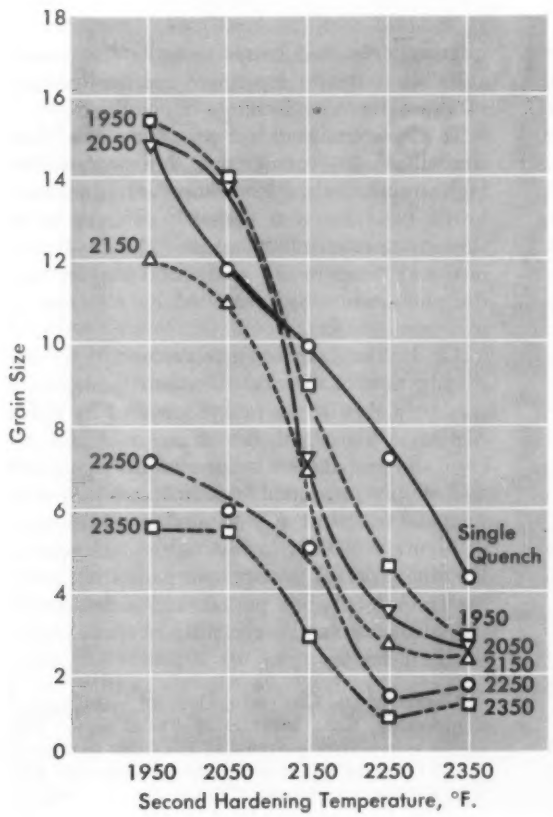


Fig. 2 – Effect of Double Hardening. The original austenitizing temperatures are indicated

Conclusions

We think, therefore, that discontinuous coarsening is related to the state of the proeutectoid carbides. These effectively inhibit grain growth, and when the amount is reduced by solution and coalescence, some of the grains grow while others are restrained. A duplex condition results, and relatively coarse grains are formed together with uncoarsened grains.

Embrittlement by Hydrogen and Other Interstitials

*By ALEXANDER R. TROIANO**

Hydrogen embrittlement is sensitive to strain rate and temperature. The kinetics of delayed failure involve an incubation period for initiation, followed by discontinuous crack propagation to catastrophic failure. Delayed failure and slow strain rate embrittlement have been observed in metals other than steels and can be brought about by interstitials other than hydrogen. Slow strain rate embrittlement, strain-aging embrittlement, and brittle delayed failure are all manifestations of the same basic phenomenon. (Q26, 2-60; ST, Ti, *H*)

FOR A LONG TIME it has been known that interstitial alloying elements, in small quantities, exert a potent influence on the mechanical behavior of alloys. The elements normally considered to be interstitial are carbon, nitrogen, hydrogen, oxygen and boron, although it is likely that others, under limited conditions, may also reside in interstices of the host lattice.

Of these, carbon has received the most attention. The behavior of nitrogen is generally considered analogous to that of carbon. Oxygen and boron, strangely enough, have been virtually ignored. Recently, hydrogen has come under close scrutiny, although its influence on the mechanical behavior of steel has been known for years. The interstitial elements have in common a high diffusion rate relative to that for the substitutional elements. But, they can vary widely in other characteristics – for example, solubility, tendency to form compounds and crystal structure.

Hydrogen Embrittlement

It is well known that hydrogen can severely embrittle steel and several other metals. One of the more intriguing aspects of this embrittlement is its sensitivity to strain rate and temperature – embrittlement is enhanced by slow strain rates and elevated temperatures. These variables are mutually dependent and may be perturbated over a wide range of conditions.

To differentiate this type of ductility loss from the more conventional behavior, where high strain rates and low temperatures enhance brittle behavior, it is generally referred to as slow-strain-rate embrittlement. The slow strain rate and temperature sensitivity suggest that the phenomenon is controlled by diffusion of hydrogen.

All brittle failures involve initiation and propagation of cracks. Under conditions of relatively slow strain rate, controlled by diffusion of an interstitial, the times for crack initiation and propagation become highly significant and readily measureable over broad ranges of time and temperature. An analysis of this type of failure will then involve a measurement of the time for crack initiation, or more specifically the crack incubation period, and a determination of the rate and mechanism of crack propagation to failure.

*Professor and Chairman, Dept. of Metallurgical Engineering, Case Institute of Technology. This article summarizes portions of the 1959 Campbell Memorial Lecture presented at the 41st National Metal Congress, Chicago.

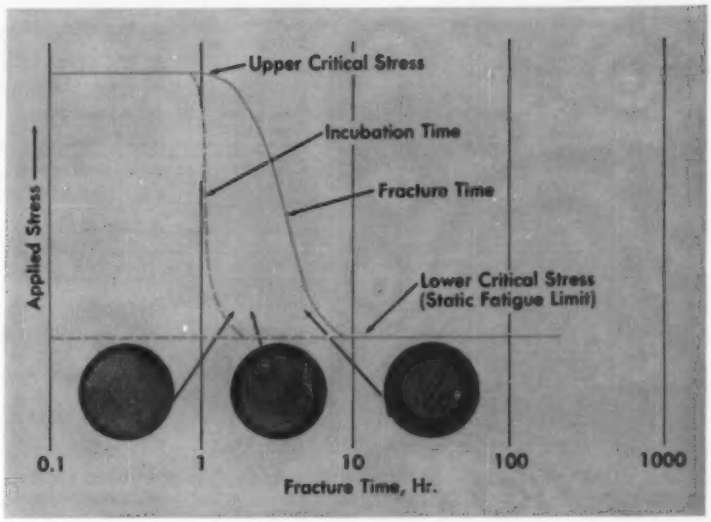


Fig. 1 – Failure Characteristics (Notch Tensile Strength) of a Hydrogenated High-Strength Steel Indicate a Process of Crack Initiation and Relatively Slow Propagation

Sustained load tests at different initial stress levels and temperatures offer definite advantages in crack initiation and propagation studies, as compared to tests where the load and stress are continuously increased, often at relatively high rates, such as in a conventional tensile or torsion test. A systematic study of this type has been in progress at Case Institute of Technology on uniformly hydrogenated steel, titanium, and other alloys.

The method of examination was simply to load a series of notched tensile specimens at different stresses, and then wait for failure.

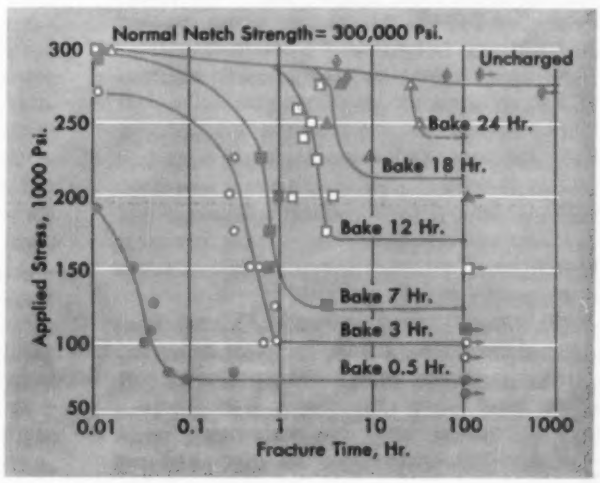
Figure 1 is typical of the kind of sustained load-to-failure curves obtained. A number of significant features should be noted:

1. Notch tensile strength may be less than normal and directly reflects the loss of ductility due to hydrogen.
2. Delayed failure may occur over a wide range of applied stress.
3. The time to failure depends only slightly upon the applied stress.
4. Perhaps the most significant characteristic of this stress-rupture relationship is that there is a minimum critical value below which failure does not occur.

The curves in Fig. 1 are, in essence, static fatigue curves, and the lower critical stress may be considered a static endurance limit – that is, a stress below which failure will not occur for an indefinite period of time.

This behavior is sensitive to hydrogen concentration, as indicated in Fig. 2, which shows that all delay failure parameters – notch strength, rupture time, and static fatigue limit – increase with decreasing hydrogen concentration. The increase in lower critical stress with decreasing hydrogen suggests that crack initiation is controlled by a combination of hydrogen and stress. With decreasing hydrogen concentration, more stress is necessary to initiate delayed failure. The concept is supported by experiments performed on specimens having varying notch severity. The static fatigue limit

Fig. 2 – How Static Fatigue Curves Are Influenced by Various Hydrogen Concentrations Obtained by Baking for Different Times at 300° F. Sharply notched specimens at strength level of 230,000 psi.



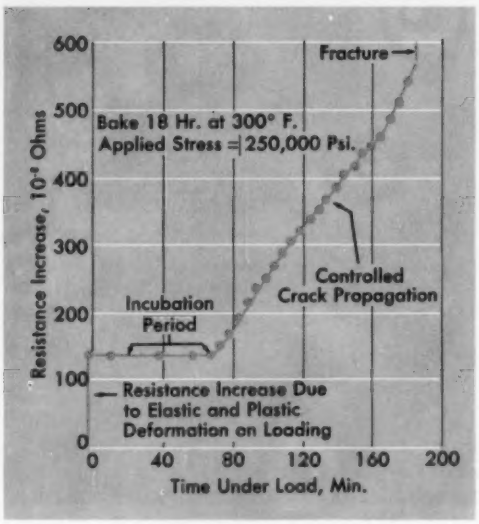


Fig. 3 — A Typical Resistivity-Time Curve for Sharply Notched Specimens. Specimens baked 18 hr. at 300° F.; applied stress is 250,000 psi.

rises as the notch severity (radius) decreases.

This strongly suggests that a critical combination of stress state and hydrogen concentration must be attained to initiate a crack. Additional support comes from an examination of the position of crack initiation as a function of the notch severity. Sharply notched specimens crack slightly below the notch bottom and less sharp notches crack more deeply.

Kinetics of Crack Initiation

Now let us consider specifically the initiation and propagation of cracks leading to failure. First we can examine events occurring prior to fracture in the static fatigue range. The cracks evidenced and the appearance of the fracture surfaces (see bottom of Fig. 1) indicate that failure occurs by a process of crack initiation and relatively slow propagation.

The kinetics of crack initiation and propagation can be followed by electrical resistance changes. Figure 3 shows a typical resistivity-time curve for sharply notched specimens. The existence of an incubation period for crack initiation and a period of apparently controlled crack propagation is apparent.

The failure process may be divided into three distinct stages, as indicated by resistivity curves: *(a)* the incubation period, *(b)* a period of relatively slow crack propagation, and *(c)* catastrophic failure with extremely rapid crack growth. The appearance of the fracture as well as the resistivity curves clearly differentiate between these latter two stages — that is, the area of slow crack growth and that of catastrophic failure. Thus, it is possible to determine the fracture stress which calculates out to be constant and about equal to the value of the fracture stress for the unembrittled material. This is true over a wide range of hydrogen concentration and applied stress. This simply means that failure of type *(c)* above is merely a high-strain-rate test; thus, there is no manifestation of hydrogen embrittlement.

Slow Crack Propagation

Let us now consider slow crack propagation. The constancy of the fracture stress, just considered, really pinpoints the role of hydrogen diffusion. The average hydrogen concentration is not sufficient to propagate a crack. In other words, crack propagation must await a localized increase in hydrogen concentration in front of the crack. This merely means that the crack progresses slowly at a rate controlled by hydrogen diffusion to a region near the crack tip.

Thus, the implication is that crack propagation is a discontinuous process and, in fact, consists of a series of crack initiations. The most severe triaxial stress state will arise just slightly in advance of the crack. When the critical hydrogen concentration is attained, a small crack forms and grows through the hydrogen-enriched region, thus joining the previous crack; further growth must await hydrogen diffusion to the new region of high stress state.

Resistivity curves taken at room temperature give only a slight hint of discontinuous growth. However, similar curves, at lower temperatures where the diffusion rate of hydrogen is retarded, yield clear evidence in support of this hypothesis, as illustrated in Fig. 4. It is apparent from the abrupt resistance increases that the crack propagates in a discontinuous manner. After each step on instantaneous growth, a plateau of constant resistance is present. The plateaus of constant resistance are then secondary incubation periods. As the temperature is lowered, the plateaus become longer and the individual crack extensions become larger, or in other words, fewer discontinuous units of crack propagation are needed to achieve failure. Finally, at −50° F., the ultimate in discontinuous propagation is attained; that is, the first crack propagates instantaneously through the specimen.

Since brittle failure is brought about by a series of crack initiations, the factors involved in controlling the incubation time should be highly

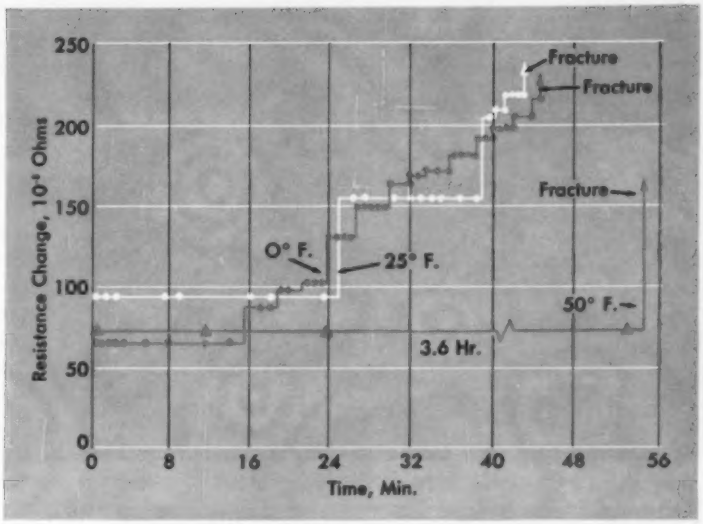


Fig. 4 — Resistance Increases With Time When Hydrogenated Specimens Are Tested in the Stress Range of Delayed Failure at Low Temperatures. It is apparent from the abrupt resistance increases that the crack propagates in a discontinuous manner

significant parameters of the basic mechanism. The initiation of a hydrogen-induced crack is dependent on two factors: *(a)* The stress-induced diffusion of hydrogen, producing an appreciable hydrogen segregation in a localized region, and *(b)* the basic influence of hydrogen on the material, causing localized cracking.

In terms of (a) above, a basic component of the incubation time is the relation between hydrogen content and the stress necessary to initiate a crack. This combination of hydrogen and stress has been referred to repeatedly so let us now separate and evaluate the specific influence of each factor. It has been demonstrated that crack incubation time is relatively insensitive to applied stress, strongly implying that the process depends primarily on developing a critical hydrogen concentration.

Low-Temperature Tests

At room temperature, as a result of stress-induced diffusion during a mechanical test, the hydrogen content at the point of crack initiation is not known. Thus, in determing the stress-hydrogen relationship to produce a crack, it is necessary to test under conditions where the hydrogen concentration is not altered during the test. Such conditions are attainable at low temperatures where the diffusion rate of hydrogen is virtually nil.

Normal tensile tests were conducted at liquid nitrogen temperature (−321° F.) and the reduction in area was used as the parameter to measure embrittlement. Hydrogen was varied by regulating the charging current density.

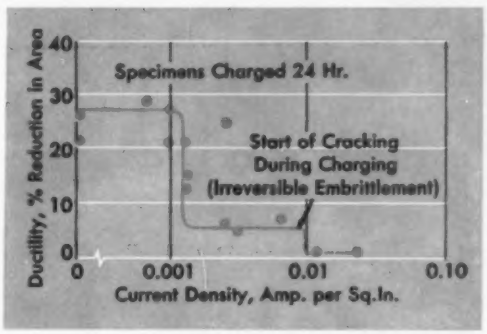


Fig. 5 — How Hydrogen Content (Log Current Density) Affects the Ductility of 4340 Steel at −321° F. Specimens were charged for 24 hr.

Figure 5 shows the influence of hydrogen content on ductility at −321° F., as indicated by the logarithm of current density. While it would be desirable to have specific hydrogen contents plotted on the abscissa, and although such values are available, certain problems associated with a precise quantitative interpretation of their significance have not yet been resolved. Nevertheless, for the argument presented here, the results clearly indicate that the relationship between hydrogen and stress necessary to initiate a crack is primarily dependent on the hydrogen content. Below some critical quantity of hydrogen, no embrittlement occurs, but when a critical content is reached, catastrophic embrittlement takes place.

The initiation of a hydrogen-induced crack above some threshold stress is therefore dependent on the development of a critical hydro-

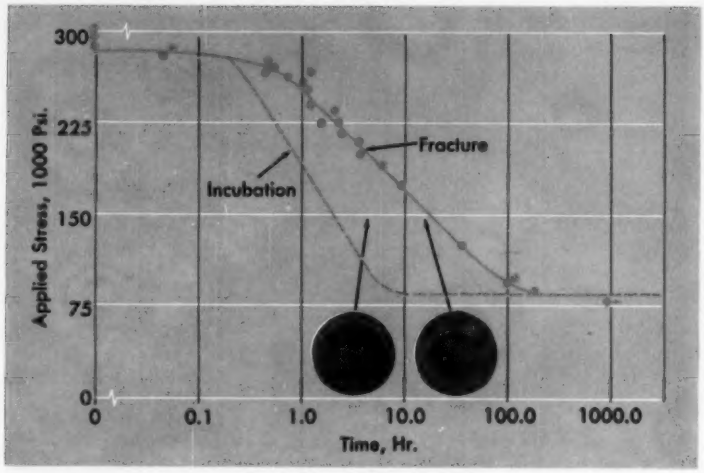


Fig. 6 — Brittle Delayed Failure Can Occur Without Hydrogen. Shown above are static fatigue characteristics (sharply notched specimen) of a high-temperature alloy steel at the 270,000-psi. strength level. Test temperature, 950° F. Composition of steel: 5.0% Cr, 1.35 Mo, 0.9 V, 1.1 Si, 0.4 C

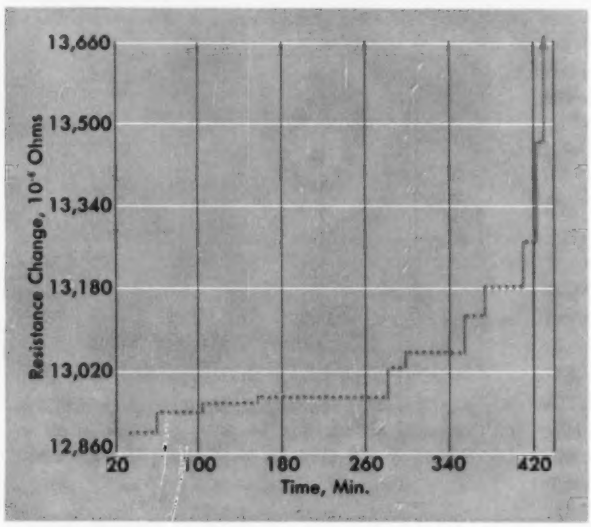


Fig. 7 — Resistivity Curve for Steel Shown in Fig. 6. Resistance increases as a function of time for high-temperature alloy steel in the stress range of delayed failure. Test temperature 950° F.

gen content, rather than a critical relationship between both hydrogen and stress. The relative insensitivity of the incubation time to the applied stress is understandable on this basis.

What, Then, Is The Role of Stress?

Presumably, the stress in the failure range influences the process primarily through its ability to produce a critical amount of hydrogen grouping in the region where a fracture embryo exists. There is, however, a minimum stress necessary to cause a critical accumulation of hydrogen; less than this will develop some segregation but not the critical amount. For dilute solutions, the equilibrium distribution of solute atoms can be described in terms of a Boltzman distribution function utilized to analyze solute segregation.*

Embrittlement in Other Alloys

Slow-strain-rate hydrogen embrittlement has been observed in titanium and its alloys displaying alpha, alpha plus beta, and beta structures. Indeed, not only has slow-strain-rate embrittlement been observed in all three structures, but the same brittle delayed-failure characteristics under sustained load, characteristic of steels, have been obtained in almost perfect analogy including incubation time and crack propagation. Slow-strain-rate embrittlement has also been observed in vanadium and columbium, and indirect evidence indicates its presence in molybdenum and possibly tantalum.

All of the metals considered thus far are body-centered cubic with the exception of alpha titanium which is hexagonal close-packed. It has generally been accepted that face-centered cubic metals will not display slow-strain-rate hydrogen embrittlement. However, recent tests in our laboratories have revealed this phenomenon in nickel and several nickel-base alloys when heavily charged with hydrogen.

*This concept and its related mathematical analysis will be discussed fully in the complete text of this lecture which will be published in A.S.M. *Transactions*, Vol. 52, 1960.

Let us now turn to some of the other interstitials. Actually, the earliest evidence of slow-strain-rate embrittlement involves the so-called blue-brittle behavior of steel, which is merely a manifestation of spontaneous strain-aging embrittlement caused by carbon and nitrogen — clearly demonstrated more than 35 years ago. Speculative logic leads to the conclusion that strain-aging embrittlement is only another facet of slow-strain-rate embrittlement or conversely.

In titanium alloys, slow-strain-rate embrittlement has definitely been correlated with strain-aging embrittlement for a number of interstitials — carbon, nitrogen, and oxygen as well as hydrogen. For several of the higher strength, hydrogenated titanium alloys, both slow-strain-rate and strain-aging embrittlement have been experimentally related (as to time and temperature) to brittle failure in a sustained load test.

If our earlier generalizations are accepted that *(a)* strain-aging embrittlement is merely a manifestation of slow-strain-rate embrittlement, and *(b)* slow-strain-rate embrittlement involves discontinuous crack propagation to brittle failure, as exemplified by a sustained load test, then the delayed failure or static fatigue type of failure should not be restricted to hydrogen. It should be a much more general phenomenon and possible for other interstitials, not to mention substitutional elements.

Brittle Delayed Failure Without Hydrogen

More specifically, one might expect brittle delayed fracture in steel caused by carbon and nitrogen if conditions are appropriate. What do we mean by appropriate conditions? First, it is apparent that the particular interstitial involved must have reasonable mobility. For hydrogen, this occurs near ambient temperatures. For carbon or nitrogen, equivalent temperatures lie in the range 700 to 1000° F. Yield strength must be above the threshold value required to attain the critical interaction energy.

With these considerations in mind, a steel was selected which did not appreciably lose its yield strength at temperatures where carbon mobility may be expected, that is, up to 1000° F. Sustained load tests were conducted at elevated temperatures. Data in Fig. 6 and 7 demonstrate that brittle delayed failure can occur without hydrogen. Here we have the typical static fatigue curve (Fig. 6) complete with crack incubation time and static endurance limit. In addition, appearance of the fracture indicates slow crack propagation. Figure 7 shows the resistivity curve, conclusively demonstrating that the process involves a crack incubation period followed by discontinuous crack propagation. Thus it becomes evident that interstitials, other than hydrogen, can bring about brittle delayed failure with a finite crack incubation period and discontinuous crack propagation. This is a perfect image of the behavior observed for hydrogen in steel at lower temperatures.

A rationalization of this behavior in terms of current, general theory on brittle fracture is not apparent. It is difficult to visualize that a dislocation pile-up which raises the flow stress to the fracture value will give rise to discontinuous crack propagation of the type observed.

Indeed, no satisfactory explanation for strain-aging embrittlement has yet been presented. With regard to the yield point phenomenon in strain aging, the Cottrell mechanism of dislocation locking by condensed atmospheres of foreign atoms provides a reasonably adequate explanation, but there is nothing in it to account for the loss of ductility in strain aging.

Dislocation locking will only bring about a rise of the flow stress with an attendant increase in strength; but strength and ductility are not, *per se*, reciprocal properties. In addition, strain-aging embrittlement always occurs in a higher temperature range than the yield point phenomenon. To be sure, there may be some overlapping. However, there is no device in theory for increasing the locking of dislocations by raising the temperature.

We offer for your consideration and future evaluation the thought that the true fracture strength, or, if you wish, the cohesive strength, of the lattice is lowered by the segregation of interstitials in the lattice at the region near the tip of the dislocation array*. This is considered to be an uncondensed atmosphere; as such it permits the array to be a more active fracture embryo and allows a greater average concentration of the interstitial over a larger volume.

The implication is strong that not only is delayed failure the result of the lowering of the true fracture strength of the lattice, but slow-strain-rate embrittlement and strain-aging embrittlement likewise result from the same phenomenon. The further implication is that, under appropriate conditions, this loss in lattice cohesion can be brought about by an interstitial or combination of such. Studies of the influence of other interstitials, particularly oxygen, from this point of view will be fruitful.

*An analysis of the mechanism by which the true fracture strength may be lowered will be given in full publication of the Campbell Lecture.

How Electroslag Welding Is Used in Russia

*By ARTHUR B. TESMEN**

Extensive work with electroslag welding in the U.S.S.R. has paid off. The process has gained a firm footing in industry and has proved economical and practical in the fabrication of heavy items where thick sections must be welded. (K6)

ELECTROSLAG WELDING, developed in the Soviet Union about ten years ago, is a fusion method for joining thick parts. Results of much development work in process and equipment improvement, and applications experience, have been published in Russian literature (see *Metal Progress*, January 1959, p. 79, and November 1959, p. 100).

In principle, electroslag welding (Fig. 1) relies on the electrical conductivity of a molten welding flux at high temperatures. A powerful electric arc is started and maintained under a layer of flux. As soon as a sufficiently thick layer of hot molten slag is formed in the welding pool, the arcless phase begins; current passes from the electrode to the workpiece through the conductive slag. Heat generated by the slag and in the molten slag-metal interface fuses the edges of the workpiece and the welding wire. The amount of heat developed in the molten pool can be determined by the formula

$$\text{Heat developed (in calories)} = 0.24 \cdot U \cdot I$$

where U = voltage drop in the slag layer (usually about 30 to 45 volts), and I = current (amperes).

Stability of the process is determined by the volume of molten slag, depth of the slag and metal pools, and characteristics of the power source. Best results are obtained from stable power sources which permit simultaneous increases in current and voltage. As shown in Fig. 1, the workpieces are located vertically, the most favorable welding position. One or more electrodes (D) are placed in the clearance between the abutting surfaces. The joint is molded by two watercooled copper plates (B) which automatically slide upward on the workpiece as welding progresses. To insure uniform weld quality, arc initiation and transition is accomplished within special starting plates (G) attached to the workpiece. The process is completed within end plates. Thus, such defects as blowholes, porosity, and slag which may form during the arc phase, the arc to arcless transition phase, and the end of the welding cycle, are located within these end plates. Upon completion of welding, the plates and defective metal are removed by gas cutting or by mechanical means. Figure 2 shows the arrangement of starting and end plates in a boiler drum joint.

*Metallurgical Engineer, Loewy-Hydropress Div., Baldwin-Lima-Hamilton Corp., New York. Consulting Editor, *Metal Progress*.

Applications and Advantages

Electroslag welding has primarily been used for joining thick-walled material such as high-pressure boiler drums, large shafts, frames for heavy presses, rolling mills and machine tools, and other components of large cross-sectional area. It has also been used for overlaying surfaces to protect them from heat and wear.

Electroslag welding permits joining metals of almost unlimited thickness (over 40 in.) in one pass without edge beveling. Welding speeds are several times that of submerged arc

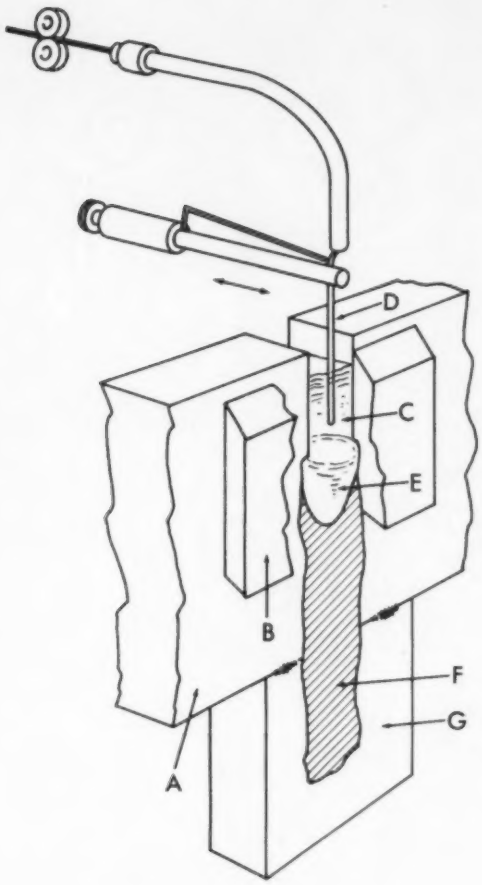


Fig. 1 – Cutaway Drawing of Electroslag Welding: A, workpiece; B, copper shoe; C, slag pool; D, electrode; E, metal pool; F, weld seam; G, starting plate

and several dozen times that of manual arc welding. Joints are structurally superior to heavy multipass arc welds due to greater weld metal uniformity, decreased contraction across joint and better stress distribution.

Melting, heating, and cooling of the base metal are more uniform, and cracking in the heat-affected zone is thereby decreased. The molten pool is well protected from atmospheric contamination by a thick slag blanket. Thus, chemical uniformity and freedom from gas and slag inclusions are assured. Flux expenditure is considerably less than in submerged arc welding.

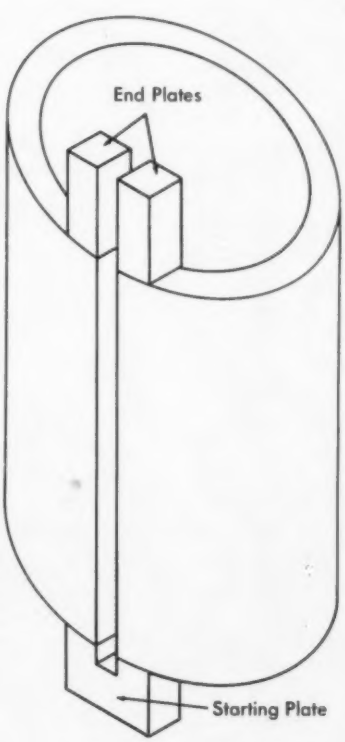


Fig. 2 – Boiler Drum Joint Ready for Electroslag Welding. Starting and end plates are removed when weld has been completed. Joint clearance is about 1 in.

Joint Preparation

Joints can be prepared by gas cutting without subsequent machining. Beveling is not required. Joint clearance is established in assembly. In joining long seams, such as longitudinal boiler drum welds, rigid reinforcing brackets are used (Fig. 3). Typical joint designs for electroslag welding are shown in Table I.

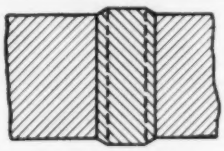
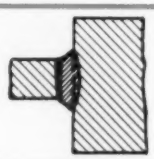
The initial and terminal plates are welded to the workpiece by manual arc welding. Whenever possible, the initial and terminal attachments are cast or forged as a part of the workpieces. Attachments, of course, cannot be provided for circular welds. Instead, welding starts in a flux layer, and the initial part of the seam is removed later by a special gas torch. A terminal pool, which acts as a hot top to take care of metal shrinkage, completes the weld. The outer surface of the weld is formed by a copper slide on the O.D. of the cylinder. It is possible to use a permanent steel back-up strip instead of the copper sliders. The strip then remains with the joint as an element of construction (Fig. 4).

Typical welding conditions for steels of various thicknesses are given in Table II. The important variables are the depth of penetration and the amount of fused base metal in the weld. The process becomes more economical with the decreasing amounts of welding wire in the weld joint, and, accordingly, more base metal in the weld.

Depth of Penetration

The depth of the weld pool increases and penetration decreases as the joint clearance is reduced. Consequently, narrow joints result in faster welding rates. Minimum joint clearance is

Table I – Joint Designs for Electroslag Welding

Joint	Methods of Molding (Forming) the Weld Seam	Method of Reinforcing Joint Prior to Welding	Sketch of Joint
Butt Joint	1. Copper sliding plates 2. Permanent steel back-strip and copper slide plate 3. Copper strip and slide plate	Brackets Clamping fixture Hydraulic jacks	
Circumferential	1. Copper slide plate on the O.D. and copper chill ring on the I.D. 2. Copper slide plate on the O.D. and a permanent back-up strip on the I.D. 3. Copper slide plates on the O.D. and I.D.	Brackets on the I.D. Clamping fixture	
T-Joint	1. Copper slide plates 2. Slide plate and copper back-up strip	Brackets Clamping fixture Short welds	
Fillets and corners	1. Copper slide plates 2. Slide plate and copper back-up strip	Brackets Clamping fixture Short welds	

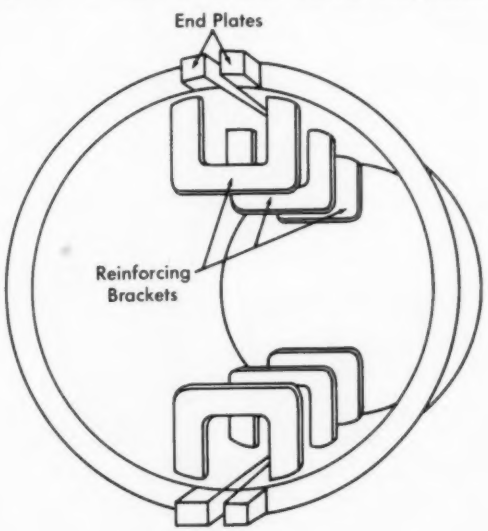
20 mm. (about 0.79 in.); maximum is 30 to 35 mm. (about 1.2 to 1.4 in.). Penetration is also dependent upon current density. With an electrode wire 3 mm. in diameter (about ⅛ in.) current should be between 400 and 800 amp. At higher current densities, the rate of wire feed sharply increases, penetration is deeper and weld cooling rate may become too high. The result: Shrinkage cracks.

An increase in the voltage drop – which is a function of the flux composition and depth of immersion of the electrode wire in the molten pool – in turn increases the welding rate and the depth of penetration. Voltage is usually maintained at about 38 to 48 volts.

Increasing the length of electrode protruding from the wire guide decreases the depth of penetration somewhat since the end of the wire heats up and its melting rate increases. Too short a protrusion may cause overheating of the guide. The average should be 50 to 100 mm. (about 2 to 4 in.). Greater oscillation rate of the electrode decreases penetration. The average rate is 30 to 50 per hr. with a 4 to 8-sec. delay at the end of each oscillation.

For best results the electrode should come within 6 to 12 mm. (about ¼ to ½ in.) of the water cooled slides during the delay period. This minimizes the temperature gradient in the slag and metal pools.

Fig. 3 – Alignment Between Workpieces Is Maintained by Reinforcing U-Shaped Brackets. Copper shoes slide along joints without interference



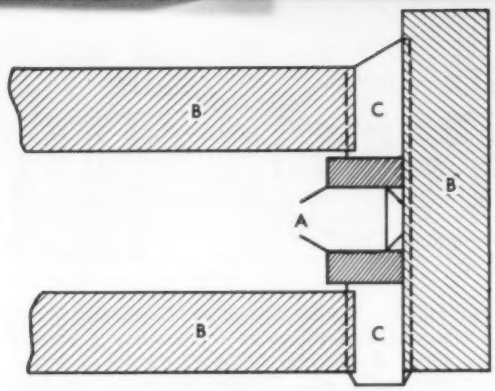


Fig. 4 – Horizontal Cross Section Through Vertical Electroslag Welds. Permanent steel back-up strips (A) replace copper slides on one side of each joint between workpieces (B). Outer surfaces of weldments (C) are molded by copper slides

Flux Properties

Flux composition influences the depth of fusion, the ease with which the process can be switched from arc to arcless during starting, the electrical conductivity and fluidity of the slag, and the shape of the weld surface.

Typical flux compositions are given in Table III. Flux expenditure is considerably less than in arc welding. Research has shown that the stability of electroslag welding increases with electrical conductivity and boiling point of the slag and decreases as viscosity and surface tension of the slag become higher.

Equipment for Welding

A typical Russian electroslag installation consists of a stand, welding head, and auxiliaries. The stand is used for positioning, supporting, and sometimes rotating the workpiece for circumferential welds.

Welding heads, either single or multiwire, feed the wire to the joint, control the movement of the weld pool along the seam, and provide the horizontal oscillating motion for the electrodes.

Auxiliaries include regulators which control the level of the weld pool. Voltage is controlled by automatic switching of the primary of the transformer, or by an ignitron contactor in the transformer circuit.

A variety of electroslag welding machines have been developed as a result of specialized applications. Gradually more universal machines have evolved, and currently several types are being standardized. Standardization is based upon requirements of versatility, dependability, accessibility, and visibility to the operator. Machines can be roughly classified according to the maximum thickness which they can weld. On this basis there are three types: machines with a single, oscillating electrode for thicknesses up to 150 mm. (about 6 in.), three-wire machines for thicknesses of 450 to 500 mm. (about 18 to 20 in.), and those which

Table II – Typical Operating Conditions for Electroslag Welding*

Metal Thickness	Number of Electrodes	Transverse Electrode Oscillations	Current	Voltage	Depth of Molten Pool
1.6 to 2.4 in.	1	none	500-600 amp.	40-42	1.8-2 in.
2.4 to 6	1	30 to 50 per hr.	500-620	42-46	2-2.4
2.4 to 4	2	none	500-600	42-46	1.8-2.2
3.2 to 4	3	none	600-620	42-46	2.0-2.8
3.9 to 18	3	30 to 50 per hr.	600-700	42-48	2.4-3.2

*Electrode diameter 0.118 in.; joint clearance about 1 in. Power transformer: single-phase with one and two electrodes; three-phase with three electrodes.

Table III – Flux Compositions for Electroslag Welding*

Identification	Developed by	SiO_2	Al_2O_3	CaO	MnO	MgO	$Na_2O \cdot K_2O$	FeO	CaF_2
FTS-7	Central Machine-Building Institute	46-48	3.0 max.	3.0 max.	24-26	16-18	0.6-0.8	1.5 max.	5-6
AN-8	Paton Welding Institute	33-36	11-15	4-7	21-26	5-7	—	1.5 max.	13-19
AN-72	Paton Welding Institute	18-21.5	19-23	12-15	7-9	11.5-15	1.3-1.7	1.0 max.	20-24

*All compositions: 0.15% S and 0.10% P max.

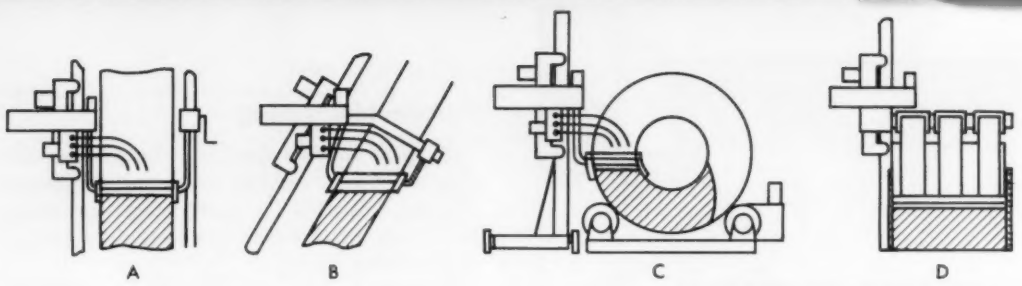


Fig. 5 – Typical Setups for Electroslag Welding of Various Joints: A, welding a vertical joint; B, welding inclined and some circumferential joints; C, circumferential welding; D, welding thick joints with plate electrodes

use plate electrodes for thicknesses over 500 mm. (about 20 in.).

Some electroslag welders are guided along rails as welding progresses. For long seams, however, rails become heavy and cumbersome. Four general machine types cover most of the current requirements:

1. The rail-less type is employed for straight butt, corner and T-welds up to 150 mm. thick (about 6 in.) and of indefinite length. This welder uses a magnetic-walking attachment described in *Metal Progress*, Nov. 1959, p. 105.

2. A heavy machine, mounted on rails, is preferred for straight and circumferential butt, corner and T-joints up to 500 mm. thick (about 20 in.). It can weld a seam 5 to 8 m. (about 16 to 26 ft.) in length and is suitable for overlay work. Typical setups for a welder of this type (A-535) are shown in Fig. 5.

3. A machine is used for compact weldments of short seam lengths (up to 1.5 m.; about 5 ft.) in thicknesses up to 1000 mm. (about 40 in.).

4. A welder with a consumable wire guide is used for complex joint configurations, repair work, heavy castings, difficult-to-reach joints, and for pieces up to 2500 mm. thick. (100 in.) using 18 electrodes.

Applications

The success of electroslag welding in Russia points out the usefulness of the process. For example, the process is employed in fabricating heavy ring flanges of 18-9 Cr-Ni stainless steel for nitrogen and oxygen regenerators. The rings are 60 to 106 in. O.D., about 5 to 8 in. thick, and 6 to 9 in. high. They weigh ½ to 2 tons. For joining the two semicircular pieces which make up the rings, the Russians use plate electrodes of the same composition as the base metal. Welding is performed with 2200 to 2400 amp. and 30 to 32 volts. Electrode feed is about 7 ft. per hr. and welding takes 10 to 20 min.

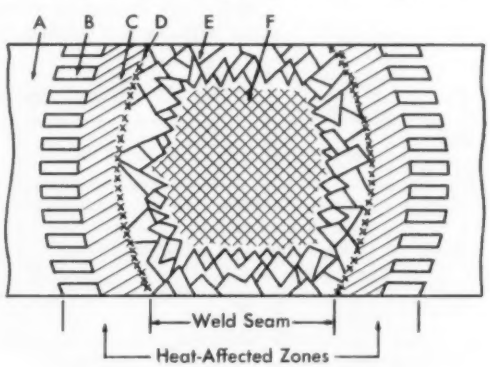
Electroslag welding is also used on thick electric motor housings and has eliminated set-up and cleaning operations required for submerged-arc welding. Man-hours spent on each piece are reduced. Flux expenditure dropped from 73 to 4 lb. and energy requirements from 72 to 3 kw-hr. Machining time was cut in half and rejects due to slag inclusions and porosity were eliminated.

Other applications include welding of high-pressure boiler drums, hydraulic and mechanical press frames and stands, hammer anvils, and turbine shafts. (Some of the resultant savings in costs and materials are described in the November issue of *Metal Progress*, p. 100.)

Post-Heat Treatment

A drawing of a typical macrostructure of an electroslag welded joint is shown in Fig. 6. Normalizing at 1740° F. followed by tempering at 1200° F. or normalizing only for low-carbon steels is sufficient to recrystallize the coarse grains in the heat-affected zone of the base metal and the columnar structure of the weld. In large weldments, local induction heating has been successfully used for post-heat treatment.

Fig. 6 – Schematic Drawing of the Macrostructure of an Electroslag Weld: A, base metal; B, area of incomplete recrystallization; C, area of complete recrystallization; D, overheated region; E, columnar grains; F, equiaxed grains



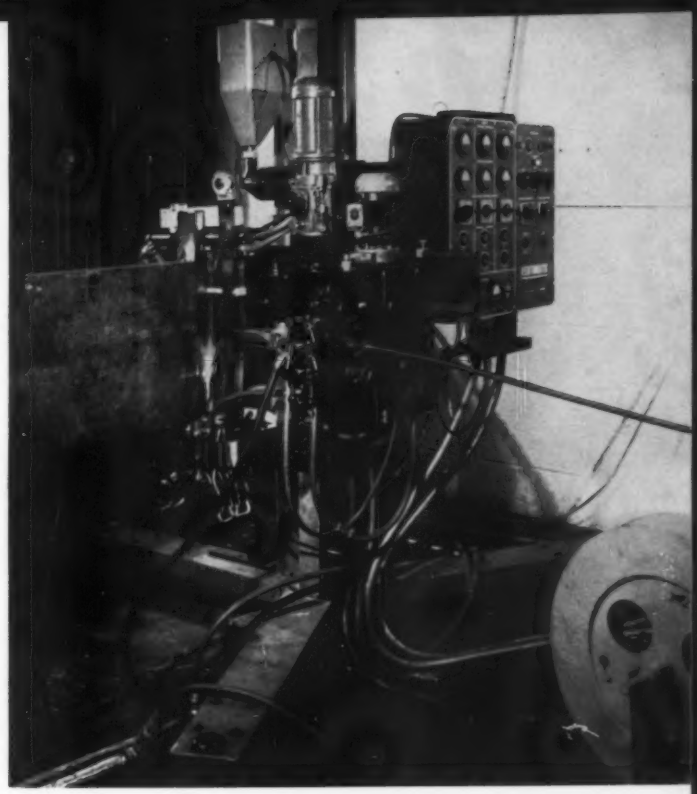


Fig. 1 — Electroslag Welder Shown Here Operating With One Wire Electrode. Entire apparatus except power transformer and relay cabinet moves up I-beam as welding progresses

Staff Report

Approach to Electroslag Welding in the United States

Its economic advantage and efficiency already proven by practical experience in Europe and Russia, electroslag welding can expect quick acceptance in this country. (K6)

ELECTROSLAG WELDING has come to the United States. Built in Belgium and available through Arcos Corp., Philadelphia, the equipment (Fig. 1) draws heavily from developments and experience on the other side of the Iron Curtain — a principle pioneered and put to work by the Russians, and a wire feed control designed by the Czechs.

Best applications for electroslag welding are in joining heavy plates over 1½ in. thick with butt, T, and corner welds, and for surface reinforcement. It has also proved useful in making circumferential welds. Here, the welding apparatus is stationary and the cylinder being welded is rotated. Equipment is portable and automatic; it operates without interruption until the complete weld is finished in one pass. There is no lost time for repositioning the workpiece or for slag removal.

With a single electrode, the equipment will deposit metal at the rate of 35 to 45 lb. per hr. With three electrodes, the maximum deposition rate is 105 to 135 lb. per hr. Table I compares submerged arc and electroslag welding speeds. Uninterrupted welding and high deposition rate mean man-hour savings on the job.

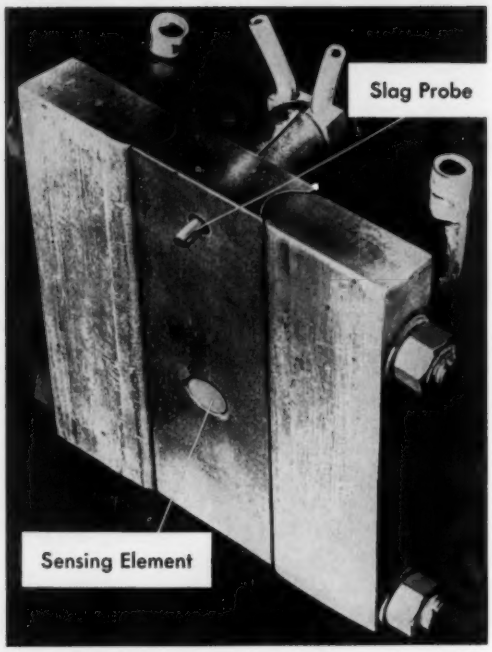


Fig. 2 – Water Cooled Shoe. Two of these – one opposite the other – slide along the joint. Upper probe controls slag replenishment; sensing element regulates vertical movement of welding apparatus

How It Works

Welds are started in a U-shaped tab (see p. 120) tack welded at the bottom of the vertical joint. The U-tab, which serves as an extension of the joint, is removed later. An arc is struck, and its heat melts a small amount of flux between two shoes, which dam the liquid slag and metal. The transition from arc to "arcless" or electroslag welding is made when sufficient flux has been melted to form a bath about ¾ in. deep. During welding this is built up to about 1½ in.

In electroslag welding, the slag bath is heated to about 3500° F. as a result of its resistance to current flow. At this temperature, the slag melts the consumable electrode and adjacent edges of the parent metal. Liquid metal then collects in a pool beneath the slag bath.

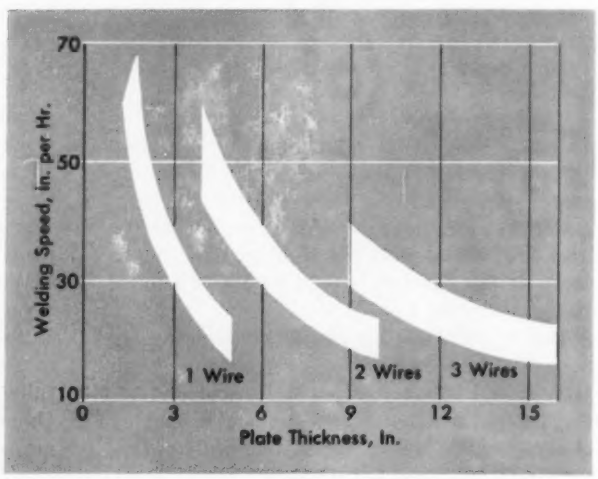
Except for the power transformer and relay cabinet, the entire welding apparatus moves vertically up an I-beam as welding progresses. Movement is automatic and is controlled indirectly through a sensing element in the water cooled shoes (Fig. 2). The shoes not only confine the molten metal and slag to the joint but also contain probes which regulate vertical speed of the machine and depth of the slag bath. One element senses the conductivity of the slag film between the weld metal and the shoe. When the film cools so that it no longer conducts, it sets the travel mechanism in motion and the machine is driven upward until the button contacts conductive slag.

Another probe, higher up on the shoe, senses the slag height and indirectly regulates flux additions from an overhead hopper. Shoes are hinged vertically in two places to allow for some misalignment of the pieces being joined. Leakage between the shoes and the workpiece is not excessive because of the self-sealing characteristics of the slag. When the weld has been completed, its outer surface is covered with a layer of solidified slag about 1/16 in. thick.

Temperature gradients in the slag bath are minimized by moving the electrode horizontally back and forth between the water cooled shoes with a short "dwell" period next to each shoe. Up to three electrodes can be used, depending on the plate thickness (Fig 3.).

Important characteristics of the flux are its melting point, fluidity, and vapor pressure at the operating temperature. Slag must be fluid at the melting temperature of the wire electrode, but its melting point must not be too low; otherwise, excessive losses due to high

Fig. 3 – Relation Between Plate Thickness and Electroslag Welding Speed With Single and Multiwire Feed



vapor pressure result. Slag compositions are similar to those used in Russia (see p. 118).

To make up for losses due to vaporization and leakage around the shoes, flux may be introduced in two ways. One method is to use a cored or composite electrode wire which contains about 5% by weight of flux. This may not supply all the make-up flux to account for losses, however, and additional flux is added automatically from the overhead hopper on signal from the probe in the shoe. The alternative method is to replenish the slag by automatic additions from the overhead hopper alone. Arcos claims that much of the beneficial effect of deoxidizers in the flux is lost when it is added to the top of the slag bath rather than being introduced as a part of the electrode wire. With composite wire, deoxidizing is more efficient and mechanical properties of the weld metal appear better.

The solidification pattern of electroslag welds is quite similar to that of ingots. Macro-etched cross sections of mild steel and manganese-molybdenum steel deposits reveal coarse columnar grains which have grown toward the center of the weldment (Fig. 4). The central portion is fine grained. How this difference in grain size from edge to center affects mechanical properties is not certain. Tests indicate that strength and elongation of the two areas are similar but that impact strength at room temperature appears superior (about 50 ft-lb. compared with 25 ft-lb.) in the region of large grains. Typical mechanical properties of electroslag welds are given in Table II.

X-ray quality of electroslag welds is excellent

Table I – Comparison of Welding Rates

Plate Thickness	Welding Method	
	Submerged Arc	Electroslag
2 3/16 in.	1.5 hr. per ft.	0.25 hr. per ft.
4 5/16	2.4	0.4*
6 3/4	5.0	0.62*

*Estimates based on experience with 3-in. plates.

Table II – Properties of Electroslag Welds

	Mild Steel	Mn-Mo Steel
Yield strength	48,700 psi.	66,000 psi.
Tensile strength	74,100 psi.	87,600 psi.
Elongation in 2 in.	28%	19%
Reduction in area	59%	43%

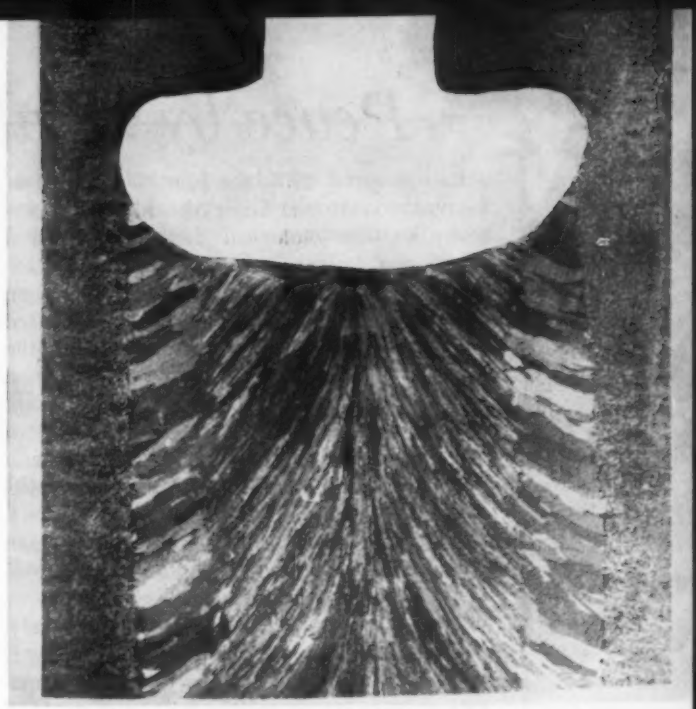


Fig. 4 – Vertical Cross Section Through the Top of an Electroslag Weld (Mn-Mo Steel). Macrograph shows the extent of slag penetration into the parent metal and typical ingot-like solidification pattern in the seam. 1.5 ×

because of the fluxing action of the slag which cleans out inclusions in the parent metal adjacent to the joint and in the wire electrodes. Another favorable characteristic is the distribution of residual stress. Weld surfaces are in compression and the center portion is in tension –an important point where fatigue is concerned.

Operating Conditions

Currently the standard wire size is ⅛ in. diameter. Each wire electrode requires a separate power transformer. Welding is carried out at 600 to 650 amp. with 45 to 55 volts. Under these conditions, the weld penetration into the base metal amounts to about 40% of the cross-sectional area of the weld. Generally, increases in voltage result in deeper penetration while increases in current give higher slag temperature. In welding large sections, no difficulty has been experienced with warpage. Contraction across the joint is small (about 3/16 in. with 3-in. thick plates, for example) and is confined to the first 18 or so inches of the weld. Surface preparation of the joint is not critical and flame cutting to give a square edge on both plates is usually satisfactory. Surfaces on which the water cooled shoes ride may require light grinding to insure a satisfactory seal.

Peace by "Balance of Terror"

Late in June, 1959, the Joint Committee of Congress on Atomic Energy heard expert testimony on the biological and environmental effects of a nuclear war. A Digest of the Testimony on Strategic Considerations has now been published by the Committee's staff, based largely on testimony by Herman Kahn of the Center of International Studies of Princeton University.

The "balance of terror" theory holds that a thermonuclear war would mean the certain and automatic annihilation of both the antagonists and that it might possibly mean the end of civilization. To some, this means that no sane man would initiate a war in which there could be no victor. Thus, it is said, the very violence of nuclear weapons will eliminate war entirely.

There are also other major implications. If both sides can utterly destroy the other, preparations to reduce casualties will be of no avail and there is no need to shoulder the financial burden of such preparations. Some people have carried this argument even further: that modern weapons are so enormously destructive that a very few of them would suffice to deter the enemy – much smaller deterrent forces than we now possess.

A very similar debate apparently took place in the Soviet Union several years ago, but the view seems to have prevailed that military expenditures must take priority over consumers' goods. Although thermonuclear war would be horrible in the extreme, other views held that it would not necessarily mean the total destruction of both sides. In the hypothetical attack, about 30% of the American population would be killed, assuming that only very primitive measures existed to protect the general population. Studies by the Rand Corp. have indicated that with certain advance measures the United States might well be able to recover almost completely from such a disaster in about 10 years, not counting the genetic damage, which would amount to 1 to 2% of future generations (which by itself would probably not be much of a deterrent to a determined enemy).

The First-Strike Advantage – The attacker would have enormous advantages. He chooses the time and method of attack. The defender must strike back with a damaged force, in the teeth of a fully alerted defense, and against an enemy population that has taken at least minimum precautions. Thus, the view of one witness was that adequate deterrence requires, first, a force that can absorb an enemy blow and still strike back with adequate strength and, second, certain minimum protection for the civilian population.

Assuming that at present the Americans and Russians have sufficient atomic weapons and delivery systems to enforce a balance of terror, Russians and even NATO nations might be led to believe that the United States would not come to the aid of Europe, attacked on the ground by Russia, *if* Soviet atomic retaliation would kill a high proportion of all Americans. What level of casualties do they believe we would accept? To the extent that the Soviets believe we can keep our casualties to a level we would find acceptable, whatever that level may be, they will be deterred not only from attacking the United States directly, but also from very provocative aggressions, such as a ground attack on Europe. Otherwise not.

"Active" deterrence is defined as the forces necessary to deter an enemy from engaging in military adventures short of a direct attack on the United States itself. How effective are nuclear weapons as an *active* deterrent? In pondering this question, it must be assumed

Book Review

An Introduction to Statistical Quality Control

*Reviewed by FRANK G. NORRIS**

STATISTICAL QUALITY CONTROL: AN INTRODUCTION FOR MANAGEMENT, by D. H. W. Allan, Reinhold Publishing Co., New York, 1959. 129 p. $3.50.

HERE IS JUST THE BOOK to recommend to a busy metallurgist (perhaps yourself or your boss) interested in getting a glimpse of modern quality control and what it can do, but not wanting to get bogged down in formulas or details of computation.

In these days of the team-approach to prob-

*Metallurgical Engineer (Statistics), Wheeling Steel Corp., Steubenville, Ohio.

that, before launching an extremely provocative adventure, the enemy would have alerted his own retaliatory forces and instituted protective measures for his population; thereby he might limit casualties to 10% of his population and one-third of his wealth. This is just about what Russia suffered in World War II, from which they had recovered by 1951. If the Soviets believed that they could limit destruction to this extent and were also convinced that the United States had failed to take the measures to similarly limit destruction in the United States, they might well feel free to launch an aggressive attack.

Relative Vulnerability – A clear advantage was attributed to the Soviet Union with respect to relative vulnerability. It has only 50 million people in its 135 largest cities, while 42 million Americans are concentrated in our 12 largest metropolitan areas, with 12 million in the New York area alone. Given the aggressor's advantage of forewarning, the Soviet Union could evacuate 80% of the people from the target areas, leaving only 10 million persons in immediate danger.

In the United States the situation is vastly different. Americans are almost totally unfamiliar with what would be required of them under conditions of a possible nuclear war. There is no experience, such as the Soviet people have undergone, of having risen from the ruins of wartime destruction to a pinnacle of postwar power. Finally, there is no comprehensive program for protecting the American people in the event of a nuclear war.

This is a lack which can prove very dangerous for the success of American and western policy against Communist aggression. For it is apparent from the testimony that the unreadiness of the American people to survive a nuclear war – well known both to the Russians and to our allies – can greatly undermine our capability to resist Soviet "nuclear blackmail".

A very moderate shelter program, which would combine protection against fallout and some blast resistance, could reduce the expected casualties to approximately one-third of those who would die if there were no protection at all. A more extensive program, designed to protect persons in our urban areas, could reduce the over-all fatalities of this attack from 25% of the population to approximately 3%. Such measures are not terribly expensive. Fallout shelters, which would go far toward saving the lives of the 60% of all Americans who do not live in or near target areas, constitute a measure which depends on simple tools and simple techniques. The lives of millions could be saved or lost by a simple choice.

The burden of the testimony was that if such protective measures were taken, the impact of America's ability to survive a nuclear war would be so great that the likelihood of such a war would be vastly reduced. On the other hand, our lack of a civil defense program could lead the Soviets to take a provocative step which we could not ignore, and a nuclear war would have started with no protection for the American people. Or, as a final paradox, the subcommittee was told that in a world of great tension the Soviets may be unable to believe that we would allow an aggressor to strike us first, which the theory of "massive retaliation" implies. The acceptance of such a military disadvantage as a basis for our national policy may seem foolish to them. They may therefore discount the sincerity of our position and expect instead that the United States actually intends to strike the first blow! A war which neither side wanted could thus break out.

lems, it becomes increasingly important to keep abreast of the terminology in fields only slightly overlapping your own specialty. If you feel this need, this book is for you. The work is complete in scope from V to E. The first word in the book is "variation". The last two words are "computing equipment". This superficial summary, "from V to E", is indeed based on a remarkably accurate sample! Well told is the story of variation and of some of the tools that make up part of the equipment for dealing with the problems of variation.

No ponderous tome is this bright essay which so well reflects the warm personality of the author. With swift broad strokes, the entire vista of applied statistics that has come to be known as quality control is spread before the reader, skillfully avoiding the details which so

often smother a spark of interest. The book can easily be read at one sitting. In fact, once it is begun, it is unlikely that the interested reader will want to lay it aside.

This book is successful in accomplishing the purpose of the publisher implied in the subtitle, "an Introduction". Its content is exactly what the title implies: A social introduction brings together two people, makes them aware of each other's names, and perhaps a bit of their background. They are then on their own, and sometimes the introduction will ripen into a friendly acquaintance to each other's mutual benefit.

The reader becomes familiar with the names of various methods. The book is not what may be termed a cook book, or an easy reference for a quick do-it-yourself statistician. Such details, if desired, must be found elsewhere. Indeed this desire is anticipated by the adequate reference list that comprises the last chapter.

Among the applications are many of interest to metallurgists and other members, namely, jigs, fixtures, tools, dies, welding, heat treating, soldering, annealing and casting.

Bacon designates three categories of books:

> "Some books are to be tasted, others to be swallowed, and some few to be chewed . . . If a man read little, he had need have much cunning to seem to know that he doth not."

Mr. Allan's book easily falls in the first class because it is quite tasty. Its rapid style makes it easy to swallow whole; certainly the implications of Chapter 8 may well be chewed and digested.

Nearly everyone who has attempted to use factual information to support a conclusion has heard the comment, "Figures don't lie, but liars can figure." The author suggests that this saying be restated thus: "Reliable figures don't lie, but unreliable figures are worthless."

The statistical point of view is emphasized throughout. Six of the eight chapter titles contain the word "statistical." The usual methods are discussed, including control charts, acceptance sampling, and a bit on linear regression. None of the common methods is conspicuous either by its absence or by undue emphasis. Less than three (small) pages are devoted to the analysis of variance and design of experiments. The reader, however, is introduced to these terms so that if he should encounter them again, he will not be a total stranger and can pursue the acquaintance further if he desires. This much is really all that can be expected of an introduction, and the book accomplishes its purpose very deftly. An introduction is intended to serve as an appetizer. The author stops just short of dulling the desire for meatier portions of the subject.

Armed with this book, you will be able to converse intelligently with experts. If you follow the advice to hire a bright young man, you may even pose as an expert yourself and help to spread the message of Statistical Quality Control as so many have done before.

Metals of High Purity

Reviewed by E. E. THUM

LIST OF HIGH PURITY METALS AVAILABLE FROM AMERICAN PRODUCERS, compiled by H. A. Wilhelm and R. E. McCarley, Offices of Technical Services, U.S. Department of Commerce, Washington 25, D.C., 1958. 55 p., $1.50

THIS LIST was prepared by Ames Laboratory for the U. S. Atomic Energy Commission and should be of the greatest value to research men studying alloying systems and the effect of impurities on the properties of pure metals. Some 51 companies in the United States and two in Canada list the analyses of their "pure" metals, the forms available, price and toxicity. (Sodium and mercury are unlisted; they are available in large quantity, sodium at 99.99% and mercury at 99.999%.)

Some of our fairly common metals are not now available in a high degree of purity; others are "six nines" or better. For example the best purity quoted in various classes are:

99.0%: Ba, Be, Sr
99.9%: Co, Fe, Li, Mn, Mo, Ni, K, W
99.99%: Al, Cr, Pd, Rh
99.999%: Au, Cu, Pb, Te, Sn
99.9999%: Ag, Bi, Cd, In, Pb, Sb

As another example, "pure" zinc is available from seven different firms with purities and prices ranging from 99.9997% at $20 per lb. to 99.99% "Special High Grade" at $1.50. Probably the present ultimate is transistor grade of silicon, containing "less than three atoms per billion of electrically active impurities" and costing $330 per lb.

Short Runs

Sizing Jig in Quench Cycle

*By E. C. BUCKINGHAM**

WITH SOME ALLOYS that require a liquid quench, there may be difficulty in obtaining uniform hardnesses and in meeting close tolerances. This problem was recently encountered at Solar Aircraft Co. when they attempted to heat treat large compressor casings of A.I.S.I. 8630 steel.

Though this steel had attractive fabricating characteristics and mechanical properties, nonuniform hardnesses and distortion during oil quenching made it difficult to make a serviceable casing. To solve the problem, a heat treating installation employing an internal sizing tool was designed. Figure 1 shows a diagram of the complete installation. The grid on which the part rests has a centering pin to locate the part accurately for final sizing during the quenching cycle. To avoid thermal shock and distortion on heating, a separate preheat chamber is used. After inserting the work in this chamber, a time control preheating cycle is performed. Next, the grid is automatically transferred to the high heat chamber for a second controlled heating cycle before quenching.

The quenching cycle consists of two distinct operations. First, the work is transferred to a preset point in the quenching chamber to position the part for the sizing tool. (This tool is shown in Fig. 2.) Once it is in position, setting of the tool and oil quenching take place simultaneously. The entire process is over in less than 9 sec.

*Industrial Div., Pacific Scientific Co., Los Angeles.

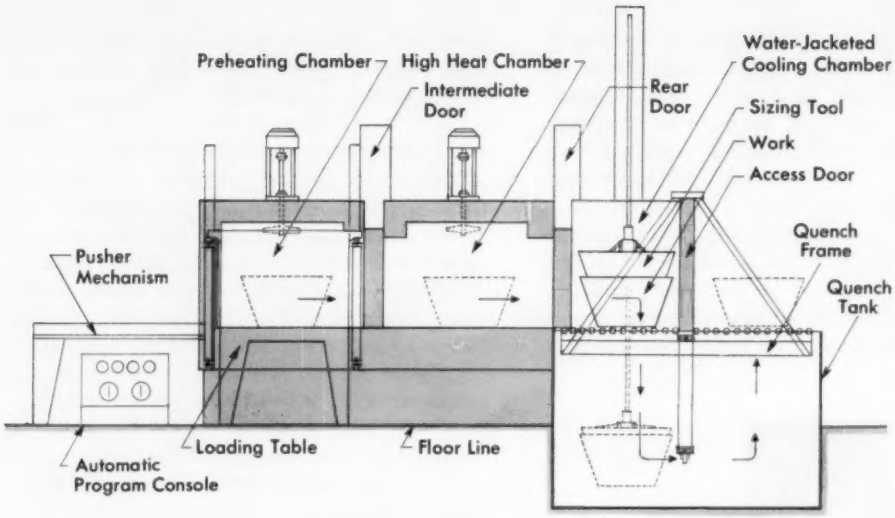


Fig. 1 — Schematic Diagram of Furnace With Quenching Jig. Basically, the furnace consists of a preheating chamber, a chamber for austenitizing, a water-jacketed cooling chamber, and an oil quenching tank with an air cylinder at the top to actuate the sizing fixture. The entire operation is completely automatic

The sizing tool, which is attached to an air cylinder located in the top of the discharge chamber, follows the part to the bottom of the tank to insure accurate dimensions of the casing after quenching. After a preset time, the sizing tool retracts and returns to the original position for the next part. Finally, the casing is transferred to the discharge rack which brings it out of the oil for draining and discharge.

The furnace is used with an assortment of

Fig. 2 — Sizing Jig Being Removed From Quenched Part. Jig helps to maintain correct dimensions and hardness during the quenching operation

sizing tools, each for a different part. By controlling preheat and quenching temperatures, furnace atmospheres, and the relative time cycles of each operation, Solar is able to maintain extremely uniform metallurgical hardness and very close tolerances throughout the part.

Preventing Magnesium Fires

WET VACUUM SYSTEMS which dampen and remove magnesium dust and chips virtually eliminate fire and explosion hazards in fine finishing. Incorporating vacuum principles (with modifications to include the use of water as a wetting agent), these systems help avoid dust accumulations.

The need for proper safety precautions is illustrated by the experience of Arlington (Texas) Industries, Inc., which produces magnesium and aluminum castings. Its plant was wrecked by a disastrous magnesium dust fire which spread the entire length of the building in less than 30 sec. Loss was more than $100,000. The company then purchased a 5-hp. Wetco-Vac portable vacuum cleaner from the U.S. Hoffman Machinery Corp., and has since had no trouble. Furthermore, production has been increased and costs lowered since less time and manpower are needed for efficient housekeeping.

Fig. 1 — Portable Vacuum Cleaner for Removing Magnesium Chips and Dust. Water wets the metal to reduce explosion hazard

The Wetco-Vac has enough capacity to operate two 1½-in. I.D. cleaning lines at the same time. All hoses are heavy duty, rubber covered and static proof. Cleaning tools and accessories are nonferrous to minimize sparking.

As magnesium dust is picked up in the hose, a dust separator with a capacity of 50 gal. of water wets and traps the material out of the air stream. Air and entrained material pass between a series of internal baffles above and below the water line. Mixing then thoroughly wets the collected materials with the nonsoluble portion settling to the bottom of the tank as sludge. This is removed periodically through a discharge valve. There are no internal moving parts, and all interior surfaces are accessible for inspection and cleaning.

For complete safety, the separator is equipped with a 16-in. combination explosion release and inspection door, an 8-in. inspection door, and an 8-in. glass porthole door as well as two 2-in. explosion vents. The Wetco-Vac can be operated continuously for 8 to 10 hr. before the water supply needs to be renewed. Though magnesium reacts with water to form hydrogen, venting prevents formation of potentially dangerous hydrogen-air mixtures.

The use of water as a precipitating medium keeps operating costs down and permits continuous wet vacuuming in virtually every part of the plant. Water does not require filtering nor can it obstruct drainage.

Motor, starting switch and electrical connections comply with N.E.M.A. standards for use where explosive dust is present. The electric cable is provided with a grounding wire to provide additional safety.

The company now uses the Wetco-Vac constantly during working hours to make absolutely certain that magnesium dust does not accumulate in any spot in the building where it could conceivably be a fire hazard. Sludge is removed and buried daily for complete safety.

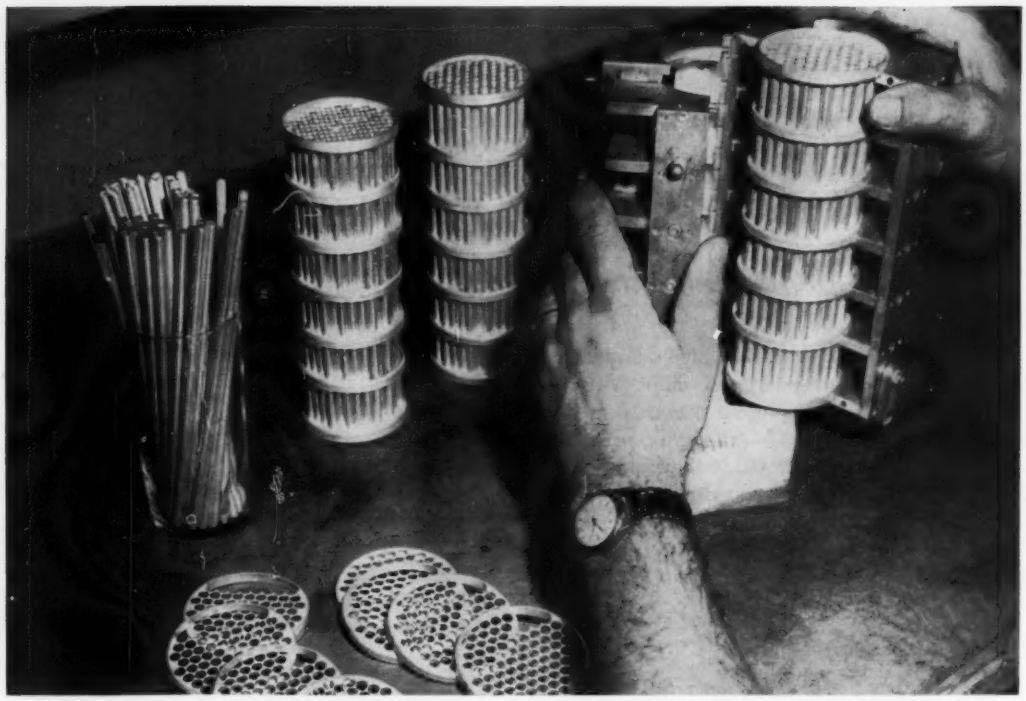


Fig. 1 – Pieces of This Heat Exchanger Are Assembled in a Fixture (Right) Prior to Brazing. Part is self-supporting and does not require jigging during preheating and dip brazing

Dip Brazing Speeds Joining

*By E. G. Slotta**

BRAZING aluminum microwave components of radar systems by hand torch is painstakingly slow and expensive. Numerous joints must usually be brazed to make one part. Quality is not uniform and overheating often results in rejection. Faced with these problems, engineers at Raytheon searched for a quicker method which would cut their production costs. The solution: Braze simultaneously all joints of a component in a salt bath. The new technique not only reduces the rate of rejection and improves part reliability, but it also does the job in one third the time for torch brazing.

In the process, all pieces of the component are first thoroughly cleaned in an etch-type aluminum cleaner. Then they are assembled so that a filler alloy may be applied to each joint (Fig. 1). The assembly must be rigid enough to remain in alignment during subsequent preheating and brazing operations. For this reason, as many components as possible are designed to be self-supporting when assembled loosely. If the pieces are not self jigging, they may be tack welded or held in specially designed fixtures of stainless steel until the joints have been brazed. The filler material, Alum-I-Braze (Handy and Harmon, New York), is applied to each joint as a paste or in its original powder form during assembly.

The component is then preheated to 950° F. for 5 to 35 min. Preheating minimizes temperature fluctuations in the salt bath where the joints are brazed.

Brazing is performed immediately after the preheat by dipping the entire assembly, including the stainless steel fixture if one is used, into a chloride-fluoride salt bath. Temperature is maintained at about 1080° F. depending on the alloy being brazed and the time required to flux the filler into each joint.

Salts are highly corrosive and each brazed component must be thoroughly cleaned. For this purpose Raytheon uses acid solutions and hot and cold water rinsing.

*General Superintendent, Manufacturing Div., Raytheon Co., Waltham, Mass.

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- . . . **that does everything oil can do up to 400° F. and that can supply exact needed quench temperatures up to 750° F. *without any fire hazard;***
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- . . . **that provides a completely automatic separating system to carry off drag-in salt, thus maintaining its exceptional quenching power.**
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Circle 496 on Page 48-A

CORRESPONDENCE

Dangerous Watches on the Loose

The American Rolex Watch Corp. has asked our help in recovering several Rolex GMT-Master wrist watches of Swiss manufacture, further identified by the name "Oyster Perpetual" on the face. It appears that about 600 of these watches were made between October 1956 and November 1959, and in some unknown manner an excess amount of radioactive material was used in the luminescent markings and numerals – an amount sufficient to present a long-term health hazard to the wearer. All owners of such watches are urged to send them by registered mail to American Rolex Watch Corp., 580 Fifth Ave., New York 36, New York, where the face will be replaced and the watch returned promptly without charge.

Discrepancies Caused by Conversion?

PITTSBURGH

In the August 1954 issue of *Metal Progress* an article by Edward M. H. Lips and H. Van Zuilen entitled "Improved Hardening Technique" described a method for imparting to steel ultra high strength along with good ductility. An example was given of the mechanical properties attained for a chromium-nickel steel (4.5% Ni, 1.5% Cr, and 0.35% C).

The authors of this article have since received a Canadian patent (No. 538783) for the process. Original application was made in January 1953. The patent also contains an example of the mechanical properties of the Cr-Ni steel mentioned above. Strength values were reported in kilograms per square millimeter.

The table below shows the mechanical properties reported in the patent and in *Metal Progress* for both conventional heat treatment and the patented technique. This shows considerable difference between the yield strengths in psi. converted from kg. per sq.mm. reported in the patent, and the values reported in psi. in *Metal Progress*.

Comparison of Property Values

	Canadian Patent		Metal Progress
	Kg. per Sq.Mm.	Converted to Psi.	
Properties When Conventionally Heat Treated			
Ultimate strength	193	275,000	—
	188	268,000	—
Yield strength (0.2%)	133★	189,000	295,000★
	145	206,000	—
Elongation	2%	—	2%
Reduction in area	5.7%	—	5%
	5.9	—	—
Rockwell hardness	C-56.6	—	C-56.5
	C-56.8	—	—
Properties Reported for New Process			
Ultimate strength	202	288,000	—
	201	286,000	—
	235	335,000	—
Yield strength (0.2%)	180†	256,000	400,000†
Elongation	11.15%	—	12%
	12.85	—	—
Reduction in area	42.1%	—	42%
	37.6	—	—
	32.7	—	—
Rockwell hardness	C-58	—	C-58
	C-59.5	—	—
	C-59.6	—	—

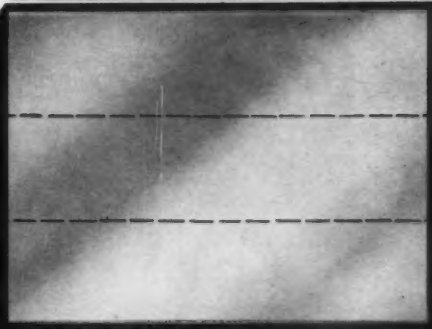
★133 kg. = 294 lb. †180 kg. = 397 lb.

*$100.00 per part production SAVINGS..... ...with the BATH METHOD

OLD METHOD

Cutting out the blank in this titanium piece was $100 extra [illegible] cost material waste in [illegible]

BATH METHOD



3 titanium parts per piece instead of one.

Drop Hammer operation resulted in heavy scrap loss.

Radial Draw Forming prior to Drop Hammer operation eliminated metal distortion, greatly reduced rejects.

Finished part

Finished part

*The illustrated titanium part was not only expensive to make by old methods, but because of metal distortion, the part reject loss was tremendous. By STRETCH RELIEVING the titanium, using a Bath Radial Draw Former, part rejects were practically eliminated . . . in short, a method of forming shapes that keep their shape . . . even after heat treating.

. Send for the plant facilities folder, it illustrates both the standard Radial Draw Forming facilities, plus a completely new series of HIGH SPEED production forming machines.

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Manufacturers of Radial Draw Formers • Stretch Draw Presses • Tangent Bending Machines • Power Type Brakes • Special Machines

Circle 503 on Page 48-A

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UNIFORM! THERMAL SHOCK RESISTANT!
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Circle 526 on Page 48-A

Correspondence . . .

The other three properties, elongation, reduction in area and hardness, are almost identical in the two publications. The ultimate strength of the steel was not reported in *Metal Progress* for either method of hardening. The footnote to the table shows that, if kilograms are converted to pounds (rather than kg. per sq.mm. to psi.), the figures for yield strength in the Canadian patent for both the conventional and new processes are quite similar to those in *Metal Progress,* except that the former are three orders of magnitude smaller. One wonders whether a mistake was not made in conversion of the values reported in *Metal Progress.**

The results reported by Lips and Van Zuilen have stimulated considerable work in attempts to verify their findings. There seems little doubt that the new technique is capable of imparting properties on the order which they report. However, in the light of work currently being conducted in this field, the results of the work carried out by Lips and Van Zuilen should be clarified.

W. L. STEINBRENNER
Graham Research Laboratory
Jones & Laughlin Steel Corp.

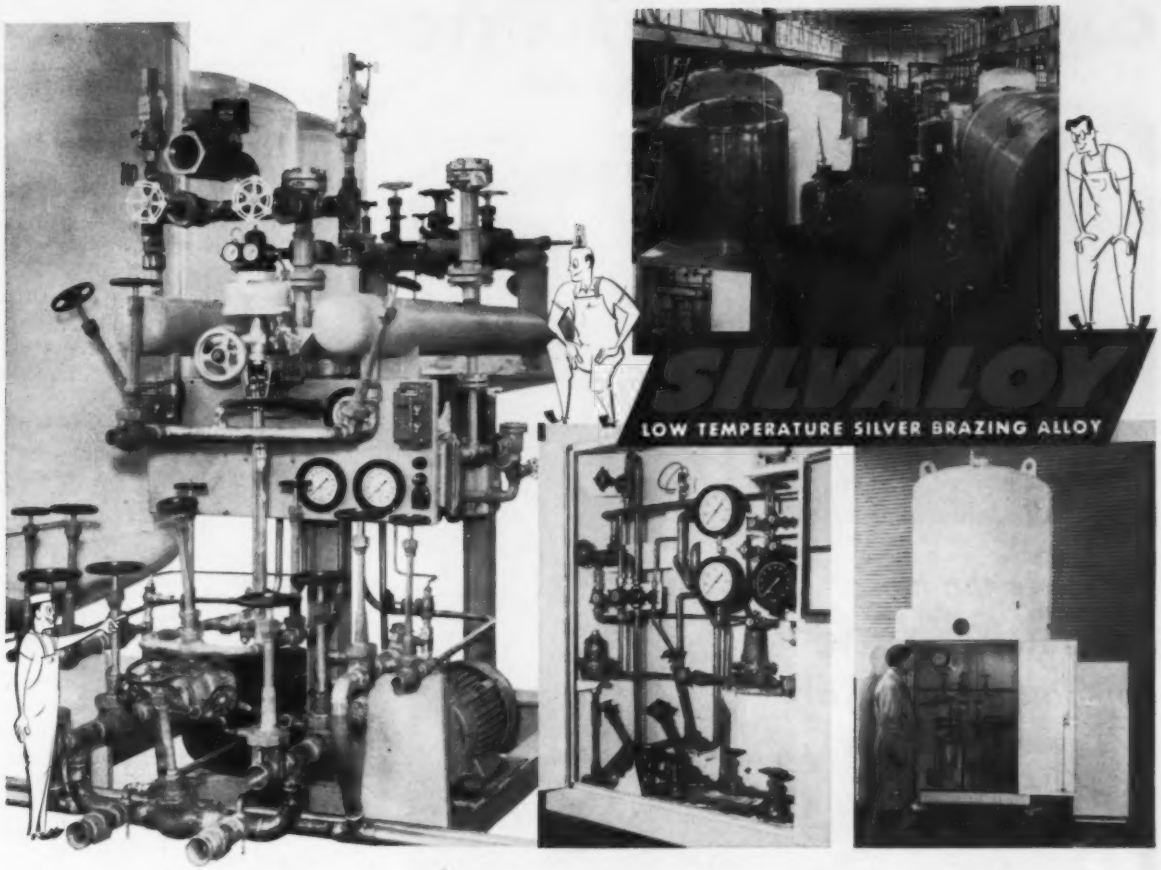
Bigger, Better and Sounder Forgings

SHEFFIELD, ENGLAND

As steelmakers who have produced many large rotor shafts, we at Thos. Firth & John Brown, Ltd., are very interested in the work carried out in the United States aimed at increasing the resistance of large forgings to brittle fracture; the two recent articles† by E. E. Thum, Editor-in-Chief of *Metal Progress,* constitute a useful summary of this work. There is no doubt that much has been achieved by cooperation between the American generator manufacturers and steelmakers in improving the quality of these large forgings.

*EDITOR'S NOTE — Unfortunately, the original manuscript is no longer in existence and cannot be checked.

†"Bigger, Better and Sounder Forgings", by Ernest E. Thum, *Metal Progress,* August 1959, p. 103 and September 1959, p. 121.



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The liquefied gas storage vessels manufactured by Ryan Industries, Inc., foremost manufacturer in this field, are subject to pressures to 500 p.s.i. — temperatures to minus 320°F. and vacuum less than 10 microns absolute pressure. The joints in the "plumbing and valving" of these vessels *must* safely withstand the extremes in temperature and pressures encountered in the storage and transfer of liquefied gases.

Ryan Industries depends upon Silvaloy Brazing Alloys and Fluxes to provide the necessary extra strength and leakproof characteristics required in joining valves, regulators, filters, thermometers, gauges, level indicators and fittings in the control cabinet. The quality of Ryan products is *insured* — with Silvaloy joints—*as strong as or stronger than the parent metals.* Silvaloy Brazing Alloys and Fluxes are helping to speed production, lower costs and improve results in many fields. Call your nearest Silvaloy Distributor for information or assistance.

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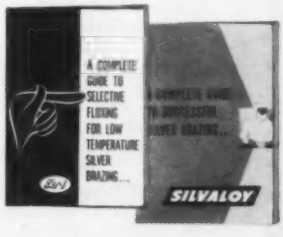

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Circle 497 on Page 48-A

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Circle 527 on Page 48-A

Correspondence . . .

Of sets made by British generator manufacturers there has, in recent years, been no failure which could be attributed to a deficiency of the rotor forgings. Two failures have been caused by nonmagnetic end bells and two have been caused by excessive overspeeding.*

The task set the forgemaster in Great Britain is perhaps a little easier than that of his American counterpart. The use of 3000-rpm. machines gives lower stresses than your 3600-rpm. machines. In addition, our forgings have not been quite so large as some of those in the United States. Both these factors reduce the stresses imposed on the rotor in operation.

As regards hairline cracks – which seem to have been mainly responsible for the failure of the Arizona and Ridgeland forgings – we are again in an easier position in that all the larger rotors are made from acid openhearth steel which is definitely less susceptible than basic electric, so that it is still possible by a diffusion heat treatment to reduce the hydrogen even in large rotors to a level which gives immunity from hairline cracking without using astronomical treatment times.

In one or two instances where comparisons have been possible, we have noted that our treatment times for forgings made from openhearth steel have been considerably longer than those used in the United States for basic electric forgings. Because of this (coupled with rigorous supersonic inspection), we have had very little trouble with hairline cracks in rotor forgings. However, the advent of vacuum casting in the United States has largely solved the problem of producing large forgings of electric steel free from hairline cracks. We might perhaps mention that, at the works with which the authors are associated, the use of a high proportion of basic electric scrap enables reasonably low sulphur and phosphorus contents to be obtained in our acid openhearth steel.

While we do not produce rotor shafts to exactly the same chemical compositions as those quoted by Mr. Thum, the tensile ductility of acid openhearth air-cast and unaged 3%

*See *Metal Progress*, July, 1956, p. 65 and December 1958, p. 114.

SOLAR AIRCRAFT'S PROBLEM:
To maintain close tolerances and uniform hardness . . . with an alloy requiring special liquid quench
THE SOLUTION:

A Pacific AUTOMATIC FURNACE

specially DESIGNED to operate internal sizing tool

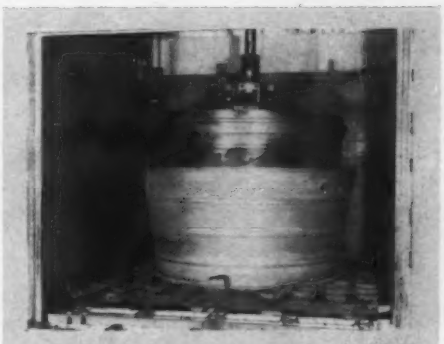
In manufacturing compressor casings, Solar Aircraft encountered a serious problem quenching AISI Type 8630 steel. Oil quenching caused non-uniform hardness and distortion, making it extremely difficult to meet very close tolerances.

The problem was solved with a Pacific Scientific furnace that inserts a sizing tool into the casing during the quenching cycle.

Operation is fully automatic. The operator puts the work on the loading table and the furnace takes over. Work moves into a pre-heating chamber first to prevent thermal shock and distortion. After a pre-set time, it moves into a high heat chamber. From there it moves into the quenching chamber where *the sizing tool is set and the work quenched in one operation.* The entire quenching cycle takes less than 9 seconds!

By automatic control of temperatures, atmosphere and relative time cycles of each operation, Solar maintains extremely uniform hardness throughout, and the very close tolerances required are held without further sizing!

This special furnace is one of many automatic furnaces designed and built by Pacific. If your requirements call for a special furnace such as this, or a standard design furnace, Pacific can be of service to you. For specific information call or write Pacific Scientific Company today!



SIZING TOOL—is attached to air cylinder located in top of discharge chamber. Ram stroke is sufficient to lower part to bottom of quench tank and thus insure accurate dimensions of casing after quenching.

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- Various sizing tools may be used to operate with different parts
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Circle 498 on Page 48-A

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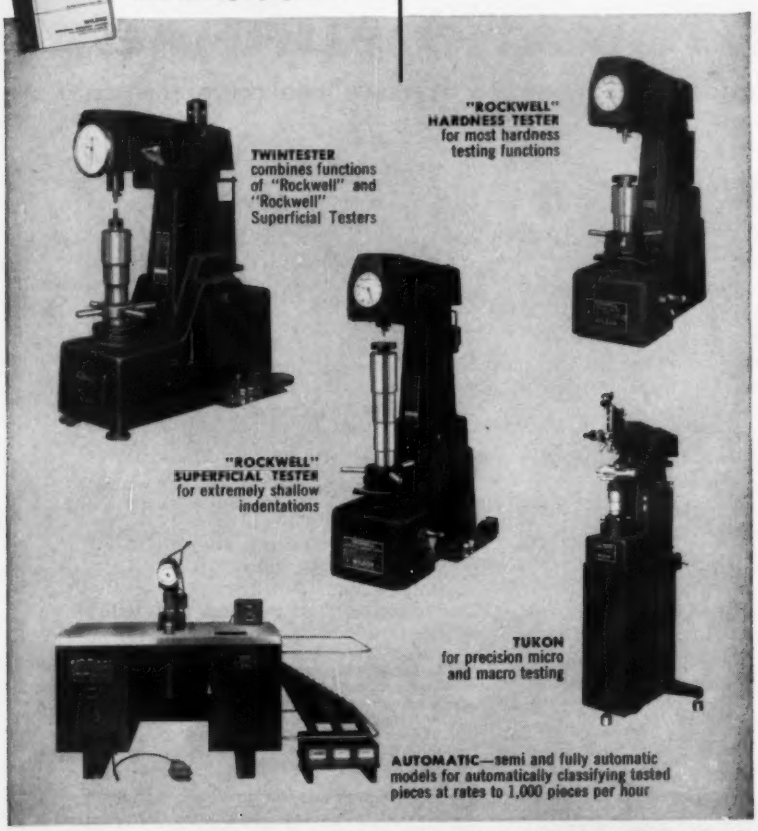
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Circle 528 on Page 48-A

Correspondence . . .

Cr-Mo are comparable, for a similar tensile strength, with the published figures on vacuum-cast, basic electric Ni-Mo-V, for example, 22% elongation and 54% reduction in area for the former and 20 to 22% elongation and 50 to 55% reduction in area for the latter.

We have also followed with interest the introduction of the vacuum casting process, as well as various other details of practice intended to eliminate hairline cracks and improve other properties. We agree that under the particular circumstances existing in America – namely, large forgings in basic electric steel – it was the wisest course to adopt for the reason mentioned above, namely, the avoidance of very long heat treatments to remove hydrogen. We should like to emphasize the point already expressed above that good rotor shafts can be, and are being, made without using vacuum casting techniques, though we agree that vacuum casting is of considerable help.

The General Electric Co. is to be congratulated on the work connected with the spinning of disks and in bringing out the importance of transition temperature on a more practical basis than the conventional impact test. The results they have obtained do emphasize the need for low transition temperatures, but probably more so, emphasize the necessity for avoiding notches both in the design and as steelmaking, forging or manufacturing defects. While not attempting to underrate the importance of transition temperature as a significant property in rotor shafts, we feel that there are definite limits (for various reasons) to what can be achieved in this direction which may be insufficient to avoid failure if the right sort of notch is present in the right place. If this is so, then the avoidance of notches of *all* types assumes even greater importance, and the work projected at Schenectady is very relevant.

On the matter of transition temperatures, investigations both in the United States and in this country have shown that the transition temperature is lowered by reducing the tensile strength (by tempering), reducing the grain size, and by tak-

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Metal products manufacturers needs for modern material handling to cut production costs and to improve control over heating and cooling cycles in metal heat treatment are being met by Despatch engineers. Illustrated here are several furnace designs that mechanize loading and unloading. Modern instrumentation provides automatic cycling, even for complex program controls.

Small quantity production and quick change-over has been considered in developing some furnace systems. These have proved popular in certain production programs.

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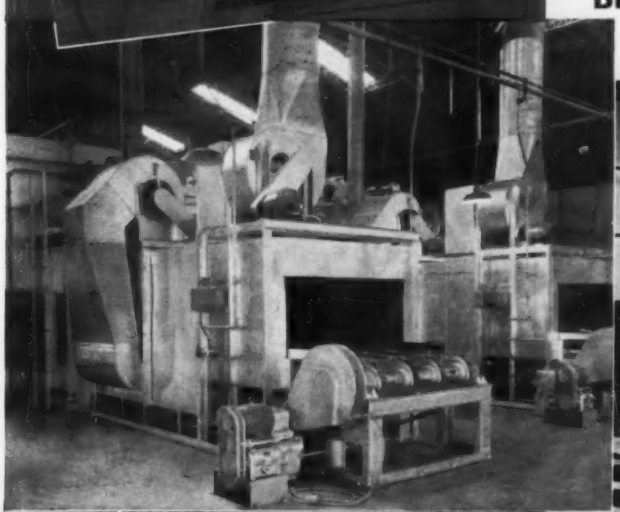

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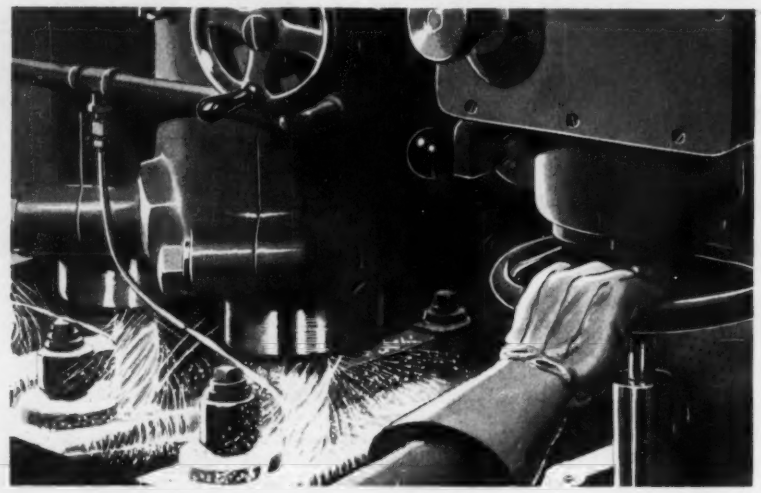

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One of a line of Oakite lubricants for machining and forming, Oakite Formula 59 is a specialized material—as all Oakite products are. Ask the Oakite man about those designed for your operations, your products. And send for Bulletin A-9864. Oakite Products, Inc., 34E Rector Street, New York 6, N. Y.

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years' leadership in industrial cleaning

Circle 529 on Page 48-A

Correspondence . . .

ing steps to obtain a low-temperature transformation product (increased hardenability or faster cooling rates). Thus, after tempering to the same tensile strength, martensite has the lowest transition temperature, bainite next, with pearlite highest.

Of these factors, the tensile strength is usually determined by the designer, but it might be pointed out that the work carried out in Schenectady and indicated in Fig. 10 of Mr. Thum's paper suggests there may be an optimum tensile strength, higher and lower tensile strengths actually resulting in a weaker rotor shaft.

The usual American steel, Ni-Mo-V, gives a fine grain size but has an inferior transformation product, this being part ferrite part bainite. One of the favorite British rotor steels, 3% Cr-Mo, gives a wholly bainitic transformation product but, with the rather high austenitizing temperatures required to dissolve alloy carbides, has a coarser grain size. On balance, fairly similar transition temperatures are obtained. For large alternators, the Ni-Mo-V composition has been found to have better magnetic properties.

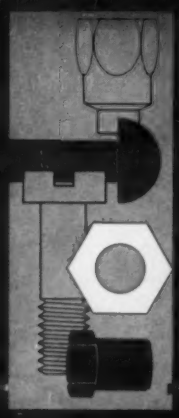
H. W. Kirkby, Director
F. W. Jones, Manager
Brown-Firth Research Laboratories

What Is a Metallurgist?

Blacksburg, Va.

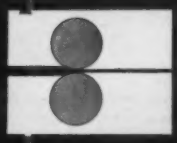
From time to time you have published definitions of metallurgy in *Metal Progress*. I would like to submit something which is not a definition of metallurgy but is a definition of a metallurgist. I picked it up recently in a book entitled "Occupations and Careers", by Walter James Greenleaf, specialist, Guidance and Student Personnel Section, U. S. Office of Education. On p. 472 the following definition of a metallurgist is given: "The metallurgist is a professional engineer who analyses ores." The book is published by McGraw-Hill Book Co. with a copyright date of 1955 and Library of Congress Card 54-62116.

John F. Eckel
Head, Department of
Metallurgical Engineering
Virginia Polytechnic Institute



COLD HEADING MACHINERY

Cold Headers • Parts Formers • Nut Formers • Slotters • Threaders • Pointers • Trimmers and other Cold and Hot Forming Equipment



ROLLING MILL MACHINERY

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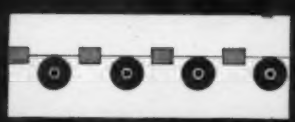
Continuous Tandem And Upright Cone Wire Drawing Machines • Bull Blocks • Wire Flattening Mills •



Swagers • Roll Pointing Machines • Spoolers • And Other Wire Equipment

POWER PRESSES

Cam and Crank Eyelet Machines • Horizontal Redraw Presses • Multiple Plunger Pillar Presses • High Speed Blanking Presses • Collapsible Tube Equipment • Ammunition Machinery, etc.

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WF-51R

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PERSONAL MENTION • PERSONAL MENTION • PERSONAL MENTION • PER
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PERSONAL MENTION

S. L. Hoyt

SAM L. HOYT (formerly head of research for A. O. Smith Corp. of Milwaukee, and long-time supervisor of welding research at Battelle Memorial Institute) has been appointed staff representative in Europe of the Department of Defense's Research and Engineering Department. His mission is to advise and consult with responsible men in NATO countries on current metallurgical problems of basic and applied research. His headquarters are in Frankfurt am Main, Germany, but his official mailing address is Army Research and Development Liaison Group (9851-DO), Army Post Office 757, c/o Postmaster, New York City.

A. R. Fairchild – from senior staff metallurgist, Western Electric Co., Winston-Salem, N.C., to department chief, manufacturing development section.

Gordon M. Doherty – to Milwaukee district sales manager for Columbia Tool Steel Co., Chicago Heights, Ill.

John A. Nelson

JOHN A. NELSON has retired as vice-president in charge of research and metallurgy of the Braeburn Alloy Steel Corp. in Braeburn, Pa., following 33 years of service. Coming to Braeburn in 1926 as chief metallurgist, he became one of the pioneers in the development of the general extrusion die steels and contributed strongly to his company's prominence in that field.

After graduating from the University of Wisconsin in 1912 with a bachelor of arts degree in both chemistry and physical metallurgy, his first experience in industry was as an analytical and research chemist at the Brotherton Iron Mining Co. in Wakefield, Mich., and the American Steel & Wire Co. in Cleveland. Joining Barber-Coleman Co. as assistant chief metallurgist in 1915, he left soon after to serve two years in the U.S. Army (including a year of duty overseas in France). He returned to the company after his discharge and in 1921 was named chief metallurgist. During his stay at Barber-Colman, he joined with other metallurgists in the area to found the Rockford Chapter.

Interested in many technical organizations, Mr. Nelson has been a member of the Tool Steel Committee of the American Iron and Steel Institute for the past ten years.

Braeburn has named **C. T. Fletcher** chief metallurgist to succeed Mr. Nelson.

James F. Murdock – from Virginia Polytechnic Institute to the staff of the Oak Ridge National Laboratory, Oak Ridge, Tenn.

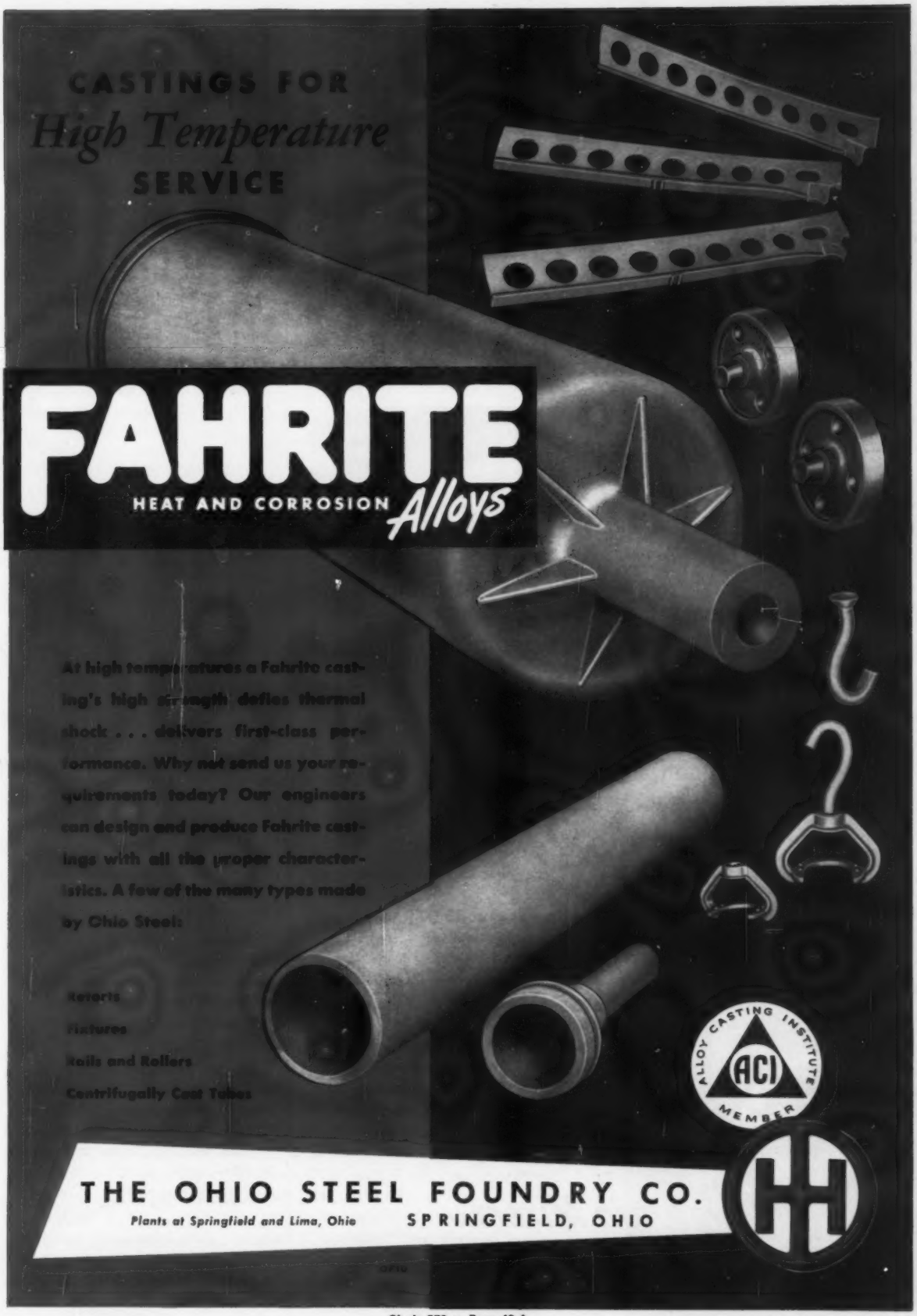
Sumio Yukawa – to supervisor, applied metallurgical research, materials and processes laboratory, in the large steam turbine-generator department of General Electric Co., Schenectady, N.Y.

Robert Steiner – to Midwest sales engineer for the research chemicals and isotopes specialties divisions of Nuclear Corp. of America, Burbank, Calif., with headquarters in Chicago.

A. R. MacVittie – from superintendent of special alloys, Alloy Works, Union Carbide Metals Co., to executive engineer of the Alloy Works.

Gurdon M. Butler, Jr. – from manager of engineering research for the Carborundum Co., Niagara Falls, N. Y., to director of research, Gladding, McBean & Co., Los Angeles.

Rand R. Hogan—from southern district sales manager, Kaiser Steel Corp., Oakland, Calif., to the newly created post of manager of sales development in the company's home office.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At high temperatures a Fahrite casting's high strength defies thermal shock . . . delivers first-class performance. Why not send us your requirements today? Our engineers can design and produce Fahrite castings with all the proper characteristics. A few of the many types made by Ohio Steel:
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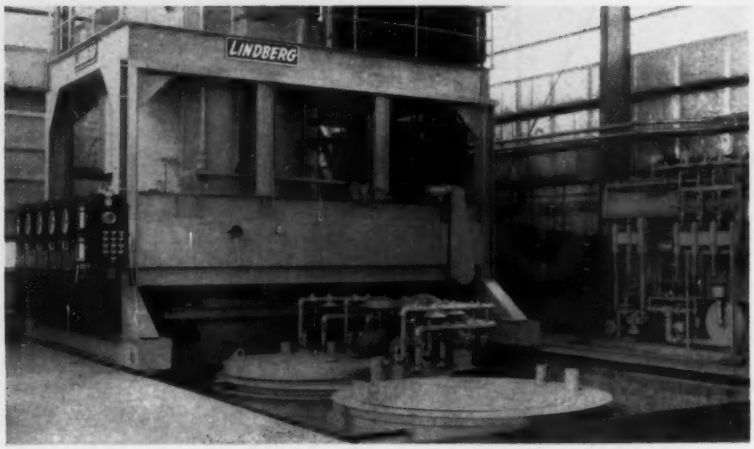
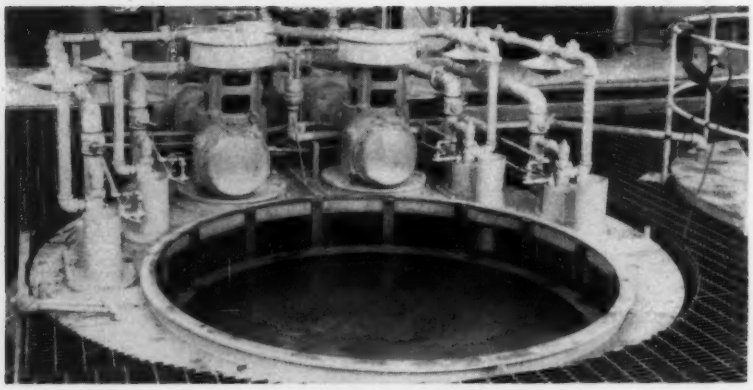
SPRINGFIELD, OHIO
OSF

Circle 570 on Page 48-A



Motor cases for a 24-foot missile go into this gantry-type furnace at Lindberg Steel Treating Company . . .



. . . and come out of these quench tanks at uniform hardness.

To get uniform quenching of 24-foot work loads Lindberg chose LIGHTNIN Mixers

The two turbine-type mixers circulate 240,000 pounds of molten salt at 400 to 1000° F over four radiant heating and cooling tubes and through the work load in the 25-foot-deep bath.

Controlled circulation insures complete transformation and promotes uniform hardness depth when quenching a work load as large as 80″ in diameter by 288″ long, weighing as much as 6000 pounds.

Installed close to the batch surface and exposed to high temperatures, each 15-hp mixer has built-in provision for water-cooling the hollow upper shaft, thus minimizing the temperature of the reducer and shaft bearing areas.

LIGHTNIN Mixers are made in sizes from 1 to 500 hp for new or existing quench tanks—for use with any quenchant, any type of immersion quenching, pieces of any size, shape, quantity. They are recommended by leading steel producers, used as standard equipment by leading furnace manufacturers. For complete information, call your nearest LIGHTNIN Mixer representative (listed in Thomas' Register) or write us.

Lightnin® Mixers

MIXCO fluid mixing specialists

MIXING EQUIPMENT Co., Inc., 171-b Mt. Read Blvd., Rochester 3, N. Y.

In Canada: Greey Mixing Equipment, Ltd., 100 Miranda Ave., Toronto 19, Ont.

Circle 530 on Page 48-A

Personals . . .

A. L. Hodge – to associate manager, development, gas processes (metallurgy), Newark (N.J.) Development Laboratory, Linde Co., division of Union Carbide Corp.

Maurice Mead – to sales representative in the Detroit sales district for Universal-Cyclops Steel Corp., Bridgeville, Pa.

Howard B. Myers, in charge of metallurgical sales, Tennessee Products and Chemical Corp., Nashville, Tenn. – elected a vice-president of the company.

John P. Denny – from specialist in physical metallurgy, general engineering laboratories, General Electric Co., to project supervisor, physical metallurgy, technical division, Beryllium Corp., Reading, Pa.

Robert D. Pehlke – appointed assistant professor of chemical engineering, department of chemical and metallurgical engineering, University of Michigan.

Richard P. Simmons – from manager of processing for Titanium Metals Corp. of America to manager of quality control for Latrobe Steel Co., Latrobe, Pa.

Joseph F. Krepley – from assistant production manager to extrusion product manager, Metals Div., Olin Mathieson Chemical Corp., New York.

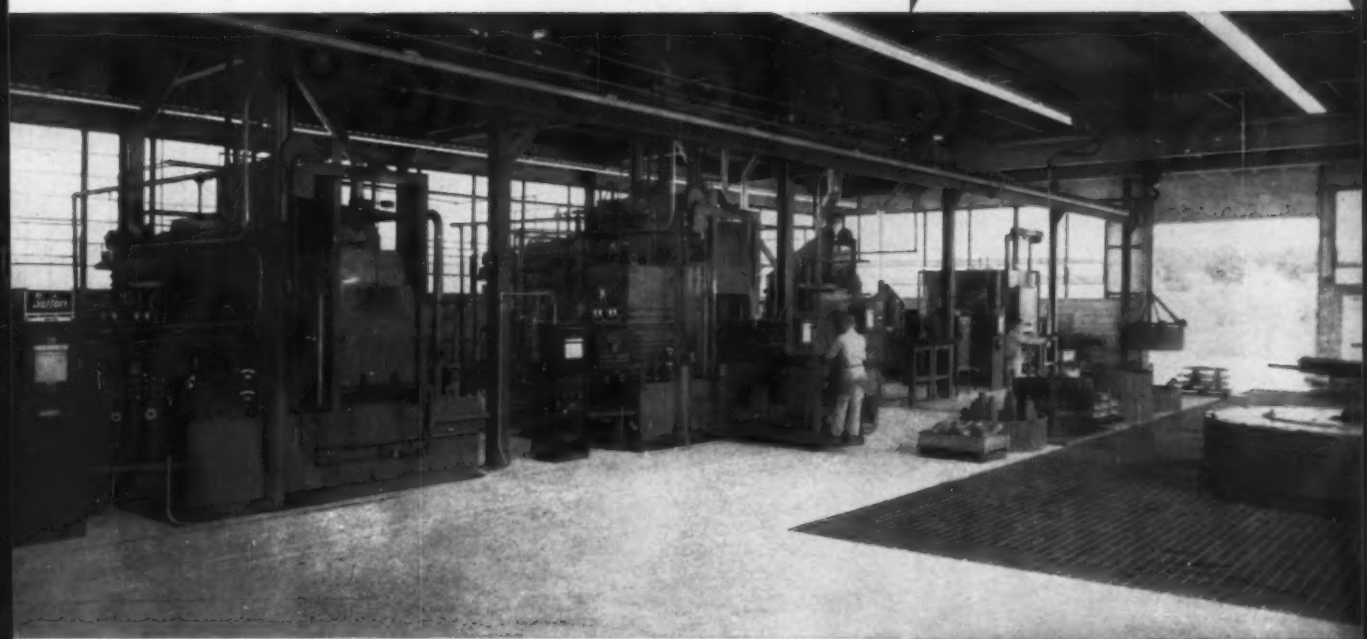
Dudley M. Hewette – from the University of Tennessee to Oak Ridge National Laboratory, Oak Ridge, Tenn.

Charles C. Dick – from chief metallurgist, Cletrac Div., Oliver Corp., to chief metallurgist of the Lakeside Steel Improvement Co., Cleveland.

H. Robert Chase – to district salesman representing the Metals Div., Kelsey-Hayes Co., New Hartford, N. Y., in western Pennsylvania, Ohio, West Virginia, Kentucky and eastern Michigan, with headquarters in Cleveland.

John V. Houston, Jr., – to assistant manager of West Coast sales and development for Climax Molybdenum Co., a division of American Metal Climax, Inc., with headquarters in Los Angeles.

stop temperature variations in high density loads with SURFACE POWER CONVECTION



Exceptional uniformity and speed of heat treating, regardless of load density, help make a consistent profit-maker of this mechanized line of Surface batch-type furnaces at The Milwaukee Gear Company.

Because of Surface Power Convection, Milwaukee Gear has much greater metallurgical control and uniformity of product than ever before. High-velocity wind penetrates the tightest loads; assures uniform heat transfer whatever the size, shape, or alloy of the work.

Carburizing case depths are hit right on the button which vary from a few thousandths to 3/16 of an inch. This unusually flexible standard rated furnace line consists of two Super Allcase® furnaces, a horizontal draw furnace, spray washer, DX® and RX® gas generators, and Autocarb® signalling dewpoint controller.

Surface Power Convection cuts cycle times to a fraction.

These advantages only suggest the profitability of Surface Power Convection. Ask your Surface representative to describe the most important development in convection heat transfer in 20 years.

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A DIVISION OF MIDLAND-ROSS CORPORATION

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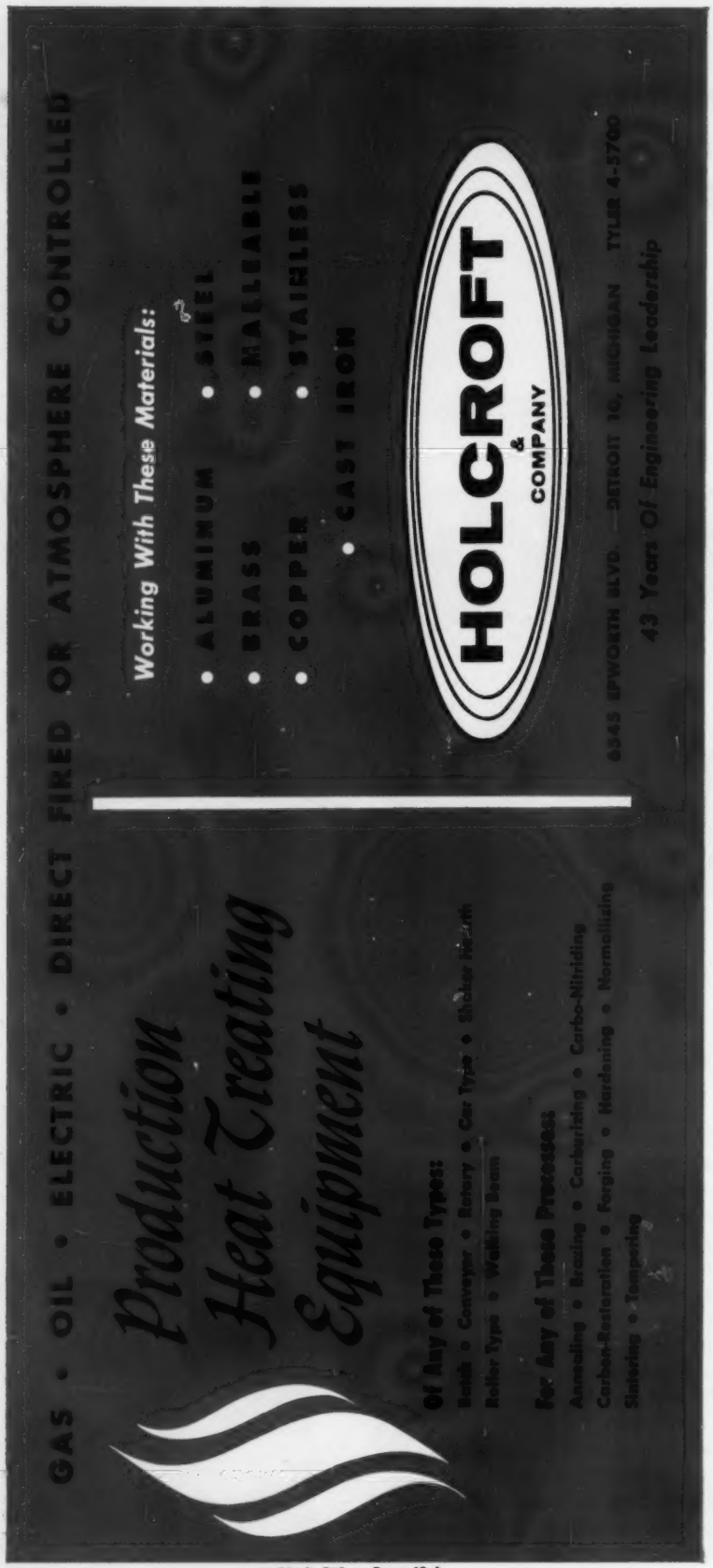

GAS • OIL • ELECTRIC • DIRECT FIRED OR ATMOSPHERE CONTROLLED
Production Heat Treating Equipment
Working With These Materials:
• ALUMINUM • STEEL
• BRASS • MALLEABLE
• COPPER • STAINLESS
• CAST IRON
HOLCROFT & COMPANY
6545 EPWORTH BLVD. DETROIT 10, MICHIGAN TYLER 4-5700
43 Years Of Engineering Leadership
Circle 531 on Page 48-A

Personals . . .

Del Steigerwald and **Jack Heimforth** – from Harshaw Scientific Div., Harshaw Chemical Co., to the board of directors, Bardel, Inc., Cleveland, responsible for expanding sales in the Michigan-Indiana area with offices in Detroit.

James F. Schumar – from associate director, metallurgy department, Argonne National Laboratory, Lemont, Ill., to chairman, metallurgy department, John Jay Hopkins Laboratory, General Atomics Div., General Dynamics Corp., located in San Diego, Calif.

Henry A. Tobey – from general factory manager, Canton and Gambrinus, Ohio, bearing factories of Timken Roller Bearing Co., to vice-president in charge of manufacturing, Bearing and Rock Bit Div.

Charles M. White, chairman of the board and chief executive officer, Republic Steel Corp. – awarded the Benjamin F. Fairless Award of A.I.M.E.

Alan C. Mattison, president, Mattison Machine Works, Rockford, Ill. – elected president of the National Machine Tool Builders' Assoc.

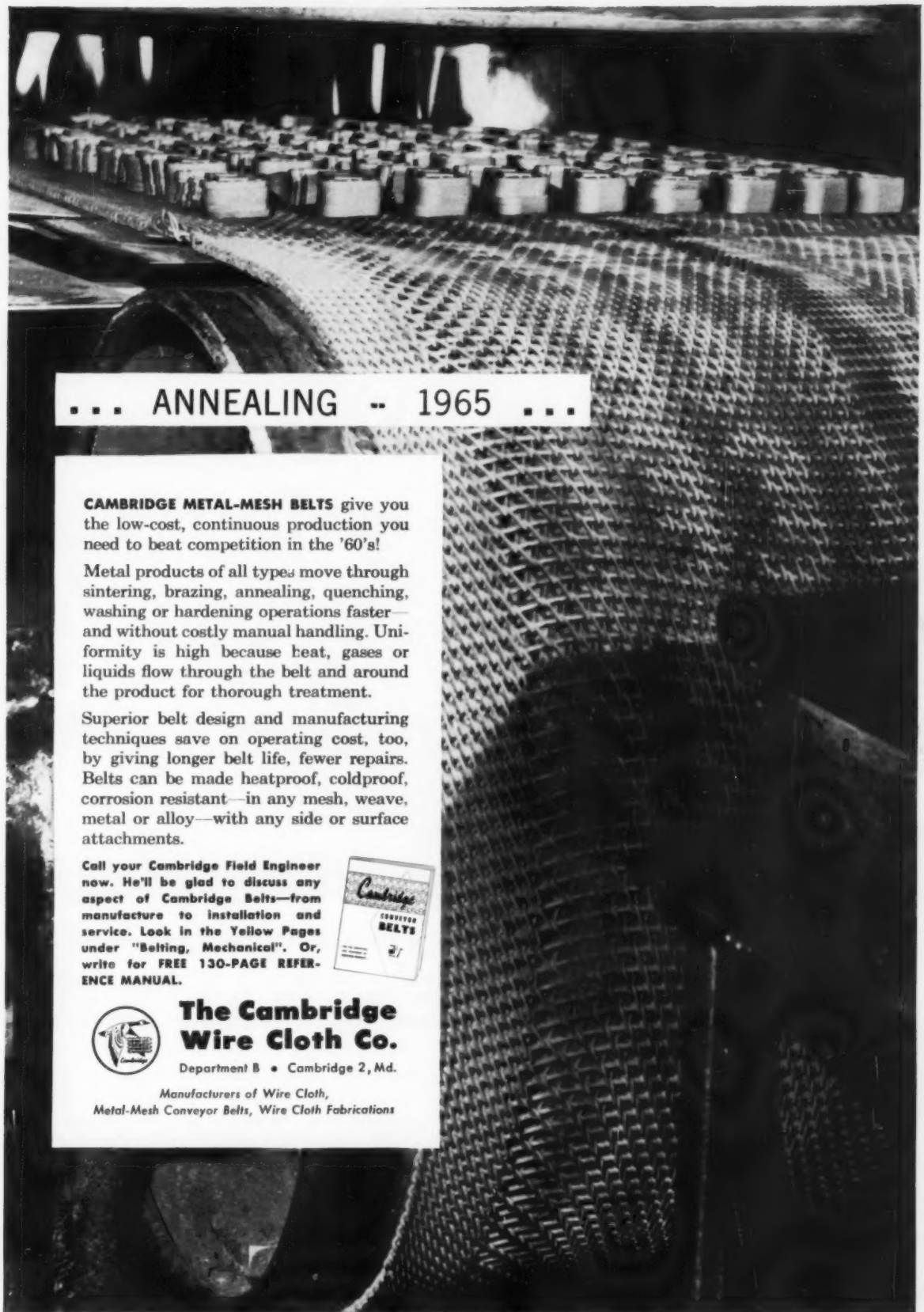
Eric R. Jette – from director of research for Union Carbide Research Institute, New York, to staff consultant to research administration for Union Carbide Corp.

James A. Hudson – from midwestern manager of gas products sales, Linde Co., New York, a division of Union Carbide Corp., to western sales manager of bulk gas sales.

Richard A. Flinn, professor of metallurgical engineering, University of Michigan – granted sabbatical leave for the 1960-61 second semester to revise two textbooks.

Roger E. Waindle, president of Waimet Alloys Co., Dearborn, Mich. – named vice-president, Technical Div., Investment Casting Institute.

Lawrence M. Van Vlack, professor of materials engineering, University of Michigan – granted a sabbatical leave for the 1960-61 first semester to study solid-state properties of ceramic materials and high-temperature ceramic-metal reactions.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CAMBRIDGE METAL-MESH BELTS give you the low-cost, continuous production you need to beat competition in the '60's!
Metal products of all types move through sintering, brazing, annealing, quenching, washing or hardening operations faster—and without costly manual handling. Uniformity is high because heat, gases or liquids flow through the belt and around the product for thorough treatment.
Superior belt design and manufacturing techniques save on operating cost, too, by giving longer belt life, fewer repairs. Belts can be made heatproof, coldproof, corrosion resistant—in any mesh, weave, metal or alloy—with any side or surface attachments.
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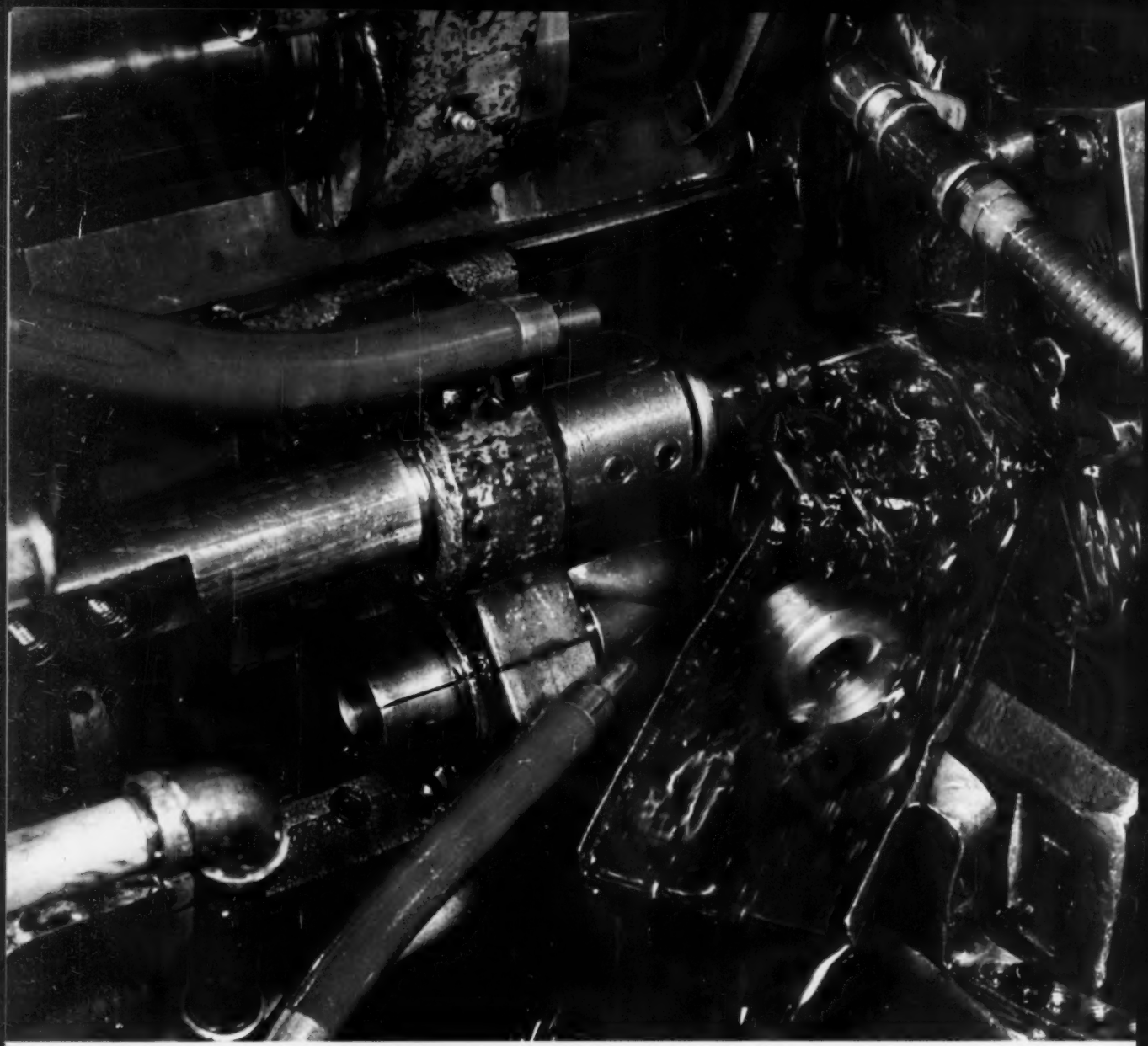

Gets closer tolerances, finer finishes, trims cutting oil cost

GULF MAKES THINGS

"We've reduced our average annual cutting oil bill 50% —and still hold closer tolerances and get finer finishes on a wide variety of precision machining jobs. We achieved this by using one cutting oil—Gulfcut 41C—which doubles as a lubricant for the working parts in our screw machines—and by using a special filtering system recommended by Gulf engineers."

So reports John R. Scott, Jr., General Foreman in the Production Department of Nippert Electric Products Company, Columbus, Ohio. Their screw machine department turns out precision-made steel cores, vee rings and lock nuts for the Nippert custom commutators and slip rings serving a wide range of industries.

Nippert operates four Acme-Gridley six-spindle automatics, a five-spindle Warner & Swasey, and a single spindle No. 4 Brown & Sharpe for machining these parts. Among the materials machined are Ledloy, leaded C-1116, leaded C-1117 and leaded C-1036. Regular brass is also used for supersonic missile parts.

"Reliable operation at higher temperatures, higher speeds, greater altitudes—these are the demands made on our Nippert commutators," says Mr. Scott. "This in turn means tighter specifications for the machined parts —closer tolerances, finer finishes—and we're getting them with Gulfcut 41C. We also have the added economy of using this same oil to lubricate the machines."

John R. Scott, Jr., General Foreman of the Production Department, with samples of various sizes of Nippert custom commutators.

NEW 100-page manual tells all about selection and usage of cutting oils. Send for your complimentary copy of "Metal Machining with Cutting Fluids."

This Acme-Gridley six-spindle automatic in the Screw Machine Department of Nippert Electric Products Company is cutting a commutator core from leaded C-1036 steel. Gulfcut 41C serves as both cutting oil and machine lubricant.

with Gulfcut®...

RUN BETTER!

In view of this dual use of Gulfcut 41C, Gulf recommended a magnetic filter coupled with a porous bronze filter. This system screens out solids to one micron, according to Otis E. Jeffries, Screw Machine Foreman.

"With this filtering system," says Mr. Jeffries, "we have lengthened cutting oil life, reduced oil-change downtime, and eliminated the risk of abrasive contaminants where Gulfcut is used as the lubricating oil."

Whatever type of machining *you* do, the Gulfcut line can meet your needs. Just call a Gulf Sales Engineer at your nearest Gulf office, or write for complimentary copy of Gulf's new 100-page manual, "Metal Machining with Cutting Fluids."

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Dept. DM, Gulf Bldg., Pittsburgh 30, Pa.

☐ Send literature on Gulfcut oils.
☐ Send copy of 100-page manual, "Metal Machining with Cutting Fluids."

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Company_____

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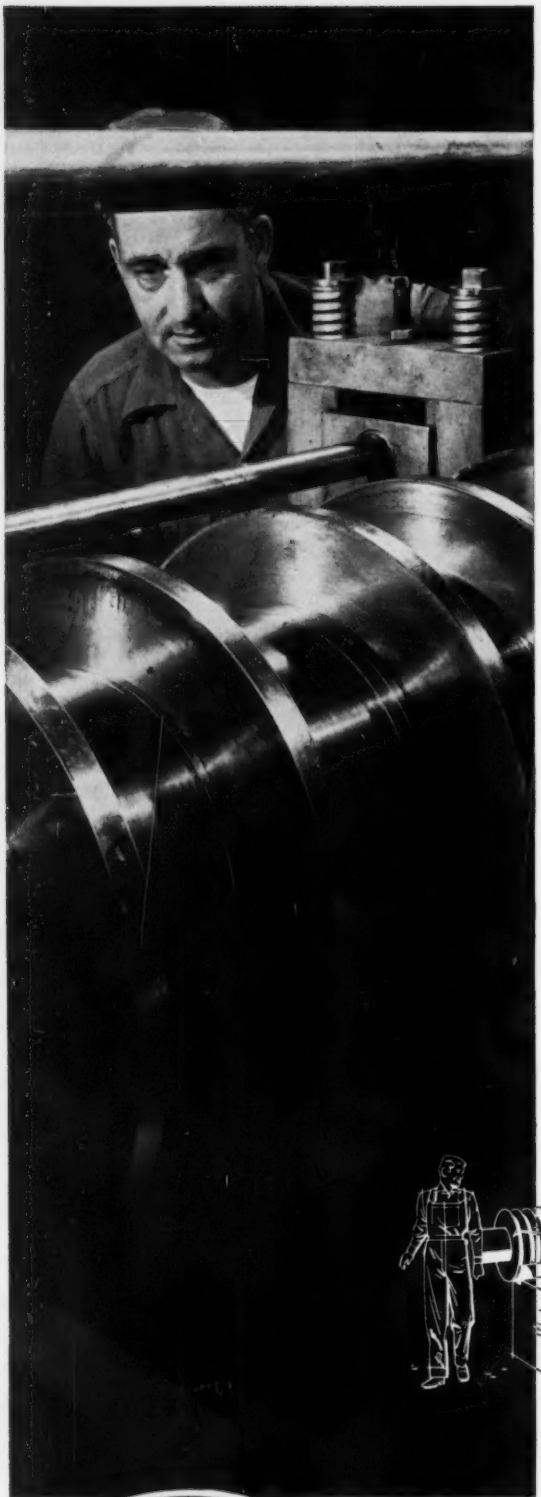

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To help meet the demands of tight production schedules, YODER Slitters reduce mill-width stock quickly and economically to desired widths. If your needs are as low as 100 tons per month, time and manpower savings alone will offset the cost of your YODER Slitter in a matter of months, while reducing basic inventories. Compactly designed, standard YODER Slitters are built to handle standard coil widths...completely engineered lines for special requirements.

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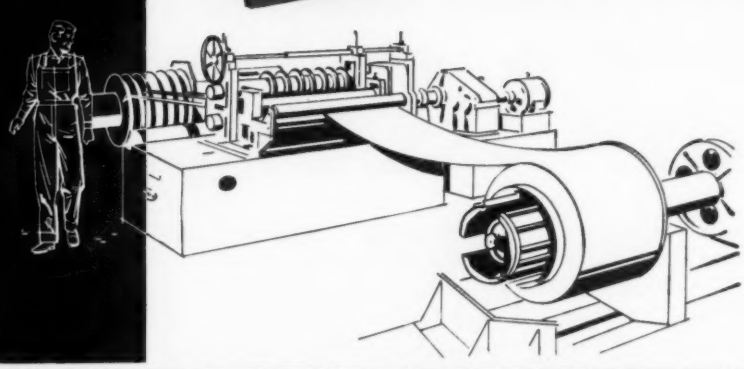


ENGINEERING **YODER** MANUFACTURING

ROTARY SLITTING LINES

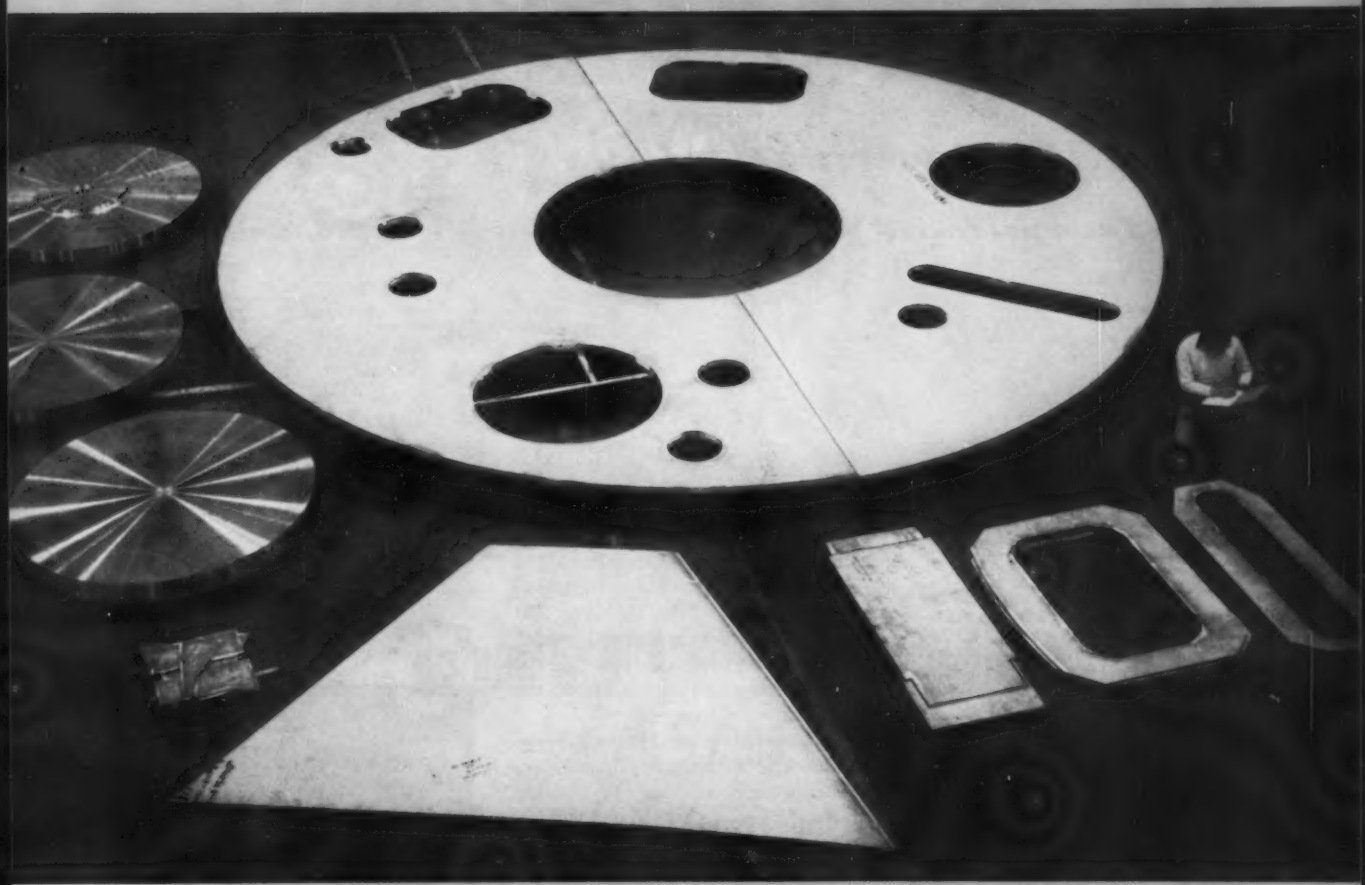
PIPE AND TUBE MILLS (ferrous or non-ferrous)

COLD ROLL FORMING MACHINES

Circle 503 on Page 48-A

OK final check

on your order for stainless steel plate from Carlson



• **Stainless steel is our only business—and we know it!** Producing to your specified tolerances in shearing, sawing, abrasive cutting, flame cutting, forming and machining stainless steel plate is a regular Carlson service. This accuracy in manufacturing saves time and money in your shop. Fabrication is easier; true-up time is cut to a minimum.

This dependable service makes Carlson a money-saving source of supply for all your stainless steel plate. You run no risk of errors which increase your costs and jeopardize your reputation and good will with your customers.

Prompt, effective service starts the moment your inquiry reaches our office. The final check of your order is done by Carlson specialists for we know your satisfaction begins right here. Take advantage of our long experience in the field. Write today, your inquiry will receive prompt attention.

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Circle 504 on Page 48-A

Metals Engineering Digest

. . . Interpretative Reports of World-Wide Developments

Aluminum Castings in Automobiles

Digest of "Applications for Aluminum Castings in the Automotive Industry", by R. F. Thomson, General Motors Corp., Detroit. Paper presented before the Purdue Casting Conference, October 30, 1959.

TODAY'S AUTOMOBILE BUYER is more aware of gas consumption than he was a few years ago. As such, he also contributes to the growth of aluminum in automotive markets. Up until 1954, improved engine efficiency offset the effect of increasing auto weight on gas economy. But since then, weight has had the upper hand and gas consumption has been on the increase (Fig. 1). This trend will probably stimulate more extensive applications of aluminum in automobiles.

Aluminum finds greatest use today in pistons and transmission parts (Fig. 2) where it totals about 106 million lb. per 5.5-million car year. The potential in these applications alone is estimated at 182 million lb. Aluminum pistons are employed in practically all automobile engines because they decrease reciprocating weight and bearing loads. This is particularly true in V-8 engines.

Aluminum alloys which contain from 9 to 24% silicon have proved popular for pistons because, as shown by Fig. 3, the coefficient of thermal expansion drops as silicon content is increased. However, machinability suffers as silicon is added and casting characteristics of the high-silicon alloys are not among the best.

Future stature of aluminum in the automotive industry is primarily dependent on economics. Its position has improved since 1945 and will become even more attractive if pig iron continues to grow in price at its present rate. A number of improvements in casting practice and alloys would open new areas of application for aluminum. For example, there is a need for die castings which not only possess good engineering properties but are free from internal defects as well. Currently scrap rate runs about 15 to 25% and even higher for those castings which must be pressure tight. This is reflected in

Fig. 1 – Relationship Between Car Weight and Fuel Economy

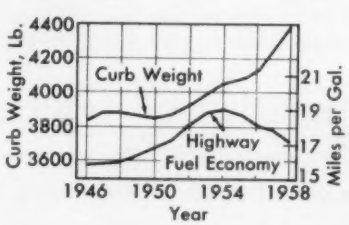


Fig. 2 – Aluminum Alloy Transmission Bell Housing

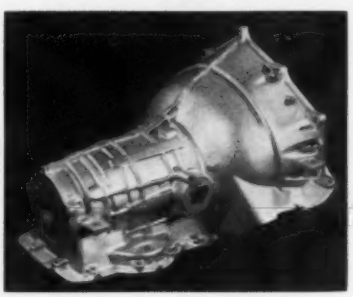
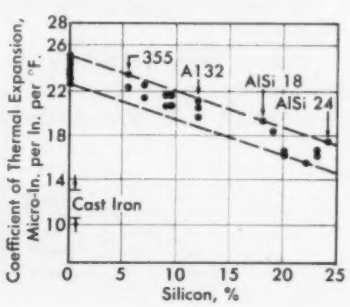
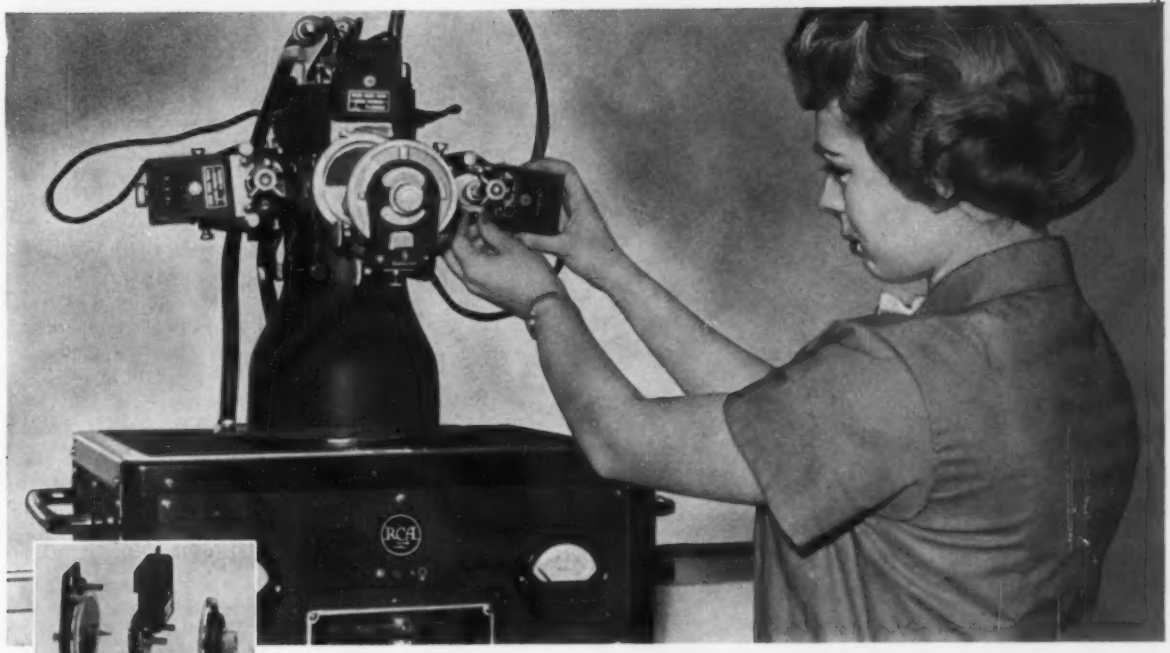


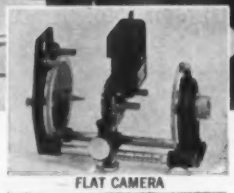
Fig. 3 – Effect of Silicon on Coefficient of Thermal Expansion of Several Aluminum Casting Alloys



SCIENTIFIC INSTRUMENTS FOR RESEARCH AND DEVELOPMENT

ANOTHER WAY RCA SERVES INDUSTRY THROUGH ELECTRONICS





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RCA also offers the Crystalloflex IV console model generator, and the world's most complete line of attachments and accessories for x-ray diffraction and spectroscopy including an exceptionally versatile group of cameras, pole figure goniometer, single crystal layer line and microfluorescence attachments.

Contract services on RCA X-Ray diffraction equipment and electron microscopes are available through eleven regional offices of the RCA Service Company.

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CAMDEN 2, N. J.

Circle 505 on Page 48-A

AO Offers Low-Cost Stereophotomicrography

. . . in just three easy steps

1 SET the focusing adjustment on your AO Spencer Cycloptic Stereoscopic Microscope, to bring specimen into sharp focus. Camera is mounted directly to Cycloptic...out of the way...ready for instant use.

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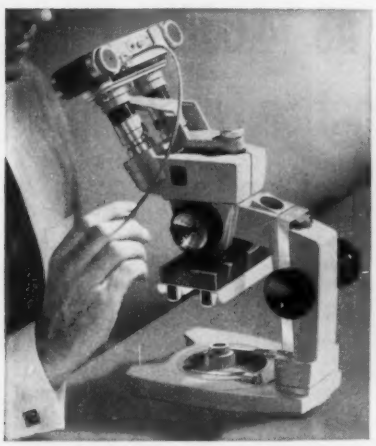
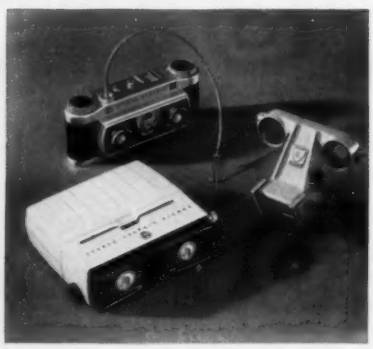


3 SNAP shutter with cable release. You photograph the sharp three-dimensional image exactly as you saw it. Your film processor will supply stereo mounted photographs. Now you have permanent, three-dimensional photomicrographs, in black-and-white or color, for future reference.



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Circle 532 on Page 48-A

Aluminum Castings . . .

the cost of the die castings. Properties also need improvement, particularly in ductility and modulus of elasticity.

Some aluminum alloys require solution heat treatment for 4 to 12 hr. followed by aging for 2 to 8 hr. To handle a "production rate of 10,000 units per day, the heat treating furnaces alone would cover more than two acres", according to one G.M. executive. Obviously, the cost advantage of a simpler heat treatment is desirable.

Core sand, either trapped or adhering to the surface of semipermanent mold castings, adversely affects the ability of a casting to carry heat away from hot areas. Core binders in use today in aluminum foundries do not break down at relatively low pouring temperatures or at solution and aging temperatures. What is needed is a binder which will disintegrate completely during heat treatment for a few hours at 300 to 400° F. because this is the temperature range within which many castings are heated for dimensional stability.

The dies used in die casting, which cost from a few hundred to over a hundred thousand dollars,

Fig. 4 – Checked Die Casting Causes Excessive Downtime While Being Reworked

have a relatively short life before becoming checked (Fig. 4). Significant improvement in unit price is possible because the capital investment in a die casting machine is high, and downtime while dies are being reworked bears directly on the casting price. Cheaper ways of making dies other than by the Kellering operation are needed also. Precision cast dies look promising.

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The XY Chart Drive Accessory — what it is:

a high performance servo system for driving the chart of the Instron recorder. Operable from most types of extensometers, including differential transformers, small synchros, resistance potentiometers and strain gauges.

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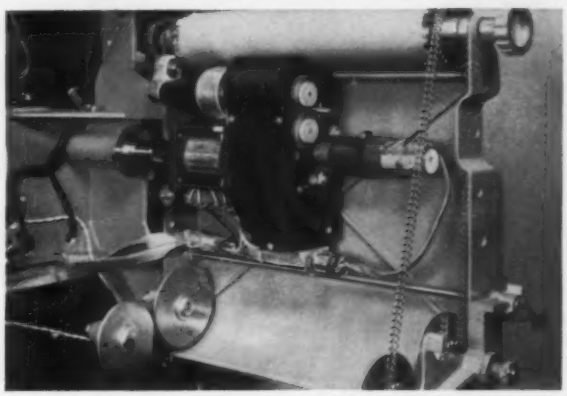
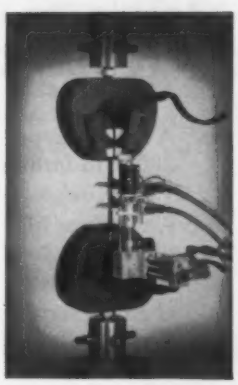


Unlimited chart travel to enable switching from extensometer to time drive for relaxation measurement.



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Circle 571 on Page 48-A

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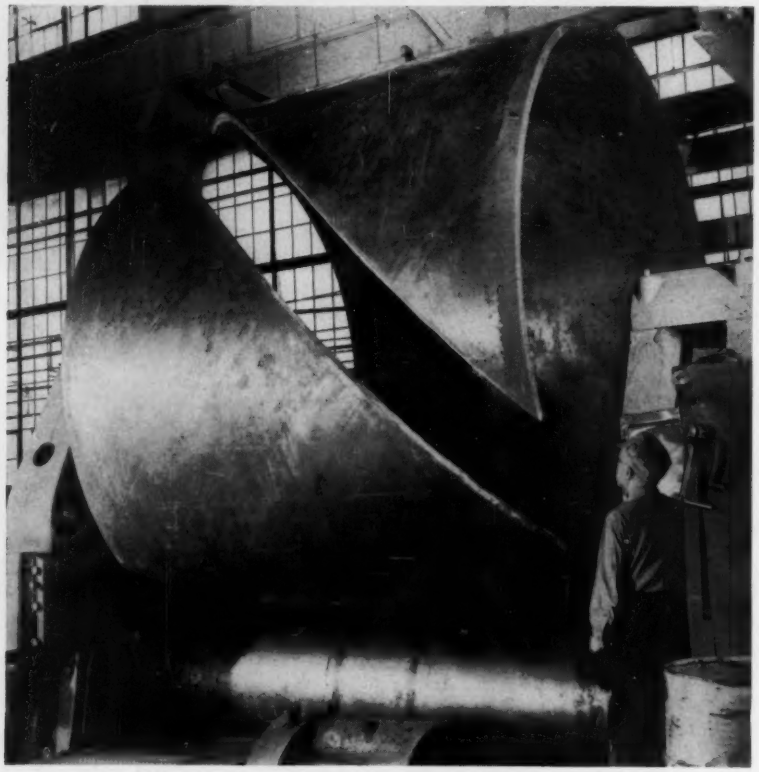

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Circle 533 on Page 48-A

Determining Weld Penetration With Radio-Isotopes

Digest of "Study of the Use of Radio-Isotopes in Welding Wire and Brazing Materials as a Means of Nondestructive Joint Inspection", by P. T. Barnes and G. L. Locher. Paper presented at the Annual Meeting of the American Welding Society, 1958.

A SPECIFIC PROBLEM requiring nondestructive determination of weld penetration arose during the development of liquid propelled aircraft rockets at the U.S. Naval Ordnance Test Station at China Lake, Calif. As a possible solution to this problem, the use of radioactive welding rod was suggested. Initially, the proposal was directed primarily toward determination of penetration in fillet welds made by automatic equipment, since in this instance the deposition of rod and radio-isotope would be uniform. It is conceivable that this method of examination might also be used for manual welds wherein bead height and width would be coordinated with the examination procedure.

Filler wire added during welding normally becomes indistinguishable from the metal being welded. Radiographic, fluoroscopic, and ultrasonic testing show various kinds of defects, but do not show the penetration. In the procedure proposed, radioactive filler wire would be used, and the weld bead would be deposited in a conventional manner. The intensity of gamma or beta radiation from a given spot of the weldment would be a measure of the amount of wire added. When monitoring is done from the side opposite the weld, the intensity of radiation then becomes a measure of penetration.

Measurement of very weak radioactivity is a highly developed technology. When the radiation receiver is very close to the source, the amount of radioactivity can be so small that it is undetectable a few feet away; this lessens hazards. A distinct advantage of the proposed method is that inspection could be made almost as soon as the work cools by a suitable radiation detection instrument. The sensing element would be a portable scintillation counter head connected to an

The Man is Sperry Ultrasonics

At Chrysler Corporation he collaborated with methods researchers to develop an improved ultrasonic inspection system. The new system, named SIMAC (Sonic Inspection Measurement and Control), automatically tests sheet steel for internal flaws in excess of 300 feet a minute. Flaws are marked by dye and the faulty steel rejected before it reaches the stamping phase. The resultant quality control assures the most perfect product with the least waste of man hours and material.

Sperry sales engineers are recognized authorities on the application of ultrasonic techniques in nondestructive testing. They are the link that sparks Sperry research and development teams to create the quality control tools industry needs.

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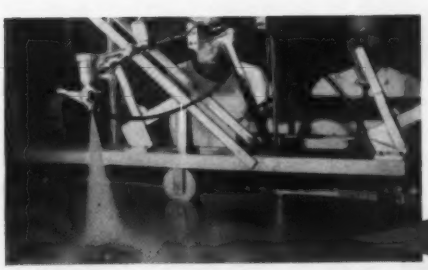

Defective sheet steel is automatically sprayed with dye on the production line at Chrysler's Nine Mile Stamping Plant

Sperry Products Company

DIVISION OF HOWE SOUND COMPANY

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Circle 586 on Page 48-A

Weld Penetration . . .

indicating recording unit. This inspection would be followed by other methods when their use was indicated, and the radioactive method would be correlated with appropriate specimens examined by metallographic methods. Interchangeable collimating apertures over the sensing element of the detection instrument would allow isolation of the area to be inspected.

In selecting suitable radio-isotopes, many materials have been ruled out because of some property that made them unsuitable or less favorable than others. Elimination of one possible isotope may be due to unsuitability of its emission, or excessive shortness of half-life, or difficulty of alloying it with the other components of the welding rod. For example, in studying welds in aluminum, it would be necessary to employ an additive element since aluminum acquires no appreciable activity from thermal neutron irradiation. Silver is favored over other possible additives since only 0.1 to 0.2% would be required, and the radiation intensity and half-life are well within satisfactory working limits. For ferrous alloys, a minute quantity of cobalt would make a good tagging element since its effectiveness is about 30 times that of silver.

The amounts of radioactivity proposed would be on the order of 0.5 to 1.0 millicuries per 1000 ft. of welding wire. Although not extremely hazardous, this intensity of radiation would require compliance with A.E.C. regulations and safety precautions normally established for low-level radio-isotope applications.

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Circle 534 on Page 48-A

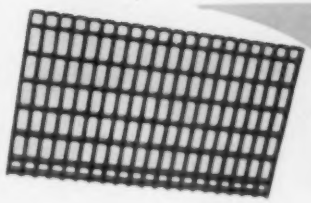
Controlling Weld Porosity

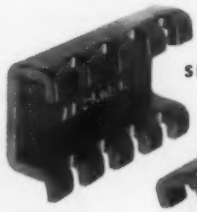
Digest of "The Control of Porosity in High Nickel Alloy Welds", by G. R. Pease, R. E. Brien and P. E. LeGrand, International Nickel Co. Technical Paper 231. 17 p.

THE GASES most important in forming weld porosity in high-nickel alloys and the conditions necessary to prevent this porosity were investigated. Commercial 99.5% nickel, Monel and Inconel were chosen, with mild steel and Types 304, 310, 321 and 347 stainless steels included for comparison.

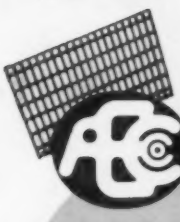
For nitrogen, oxygen and carbon monoxide, porosity effects were evaluated in weld beads laid down by the tungsten arc process without filler metal. Helium was used for shielding because it is preferred in America. Up to 10% of other gases were fed in from cylinders of premixed helium plus contaminant gases at predetermined rates, as measured by precalibrated flowmeters, at the total rate of 30 cfh. A 5/16-in. diameter thoriated tungsten electrode was used on an automatic welder at 150 amp. d-c., straight polarity. Travel speed was 16 in. per min. and arc length was 0.050 in. Porosity was inspected at 15 × on the ground, polished and etched weld beads, and each weld was compared with a series of porosity standards.

Since carbon dioxide corrodes tungsten filler rods, the argon-





Patents Pending



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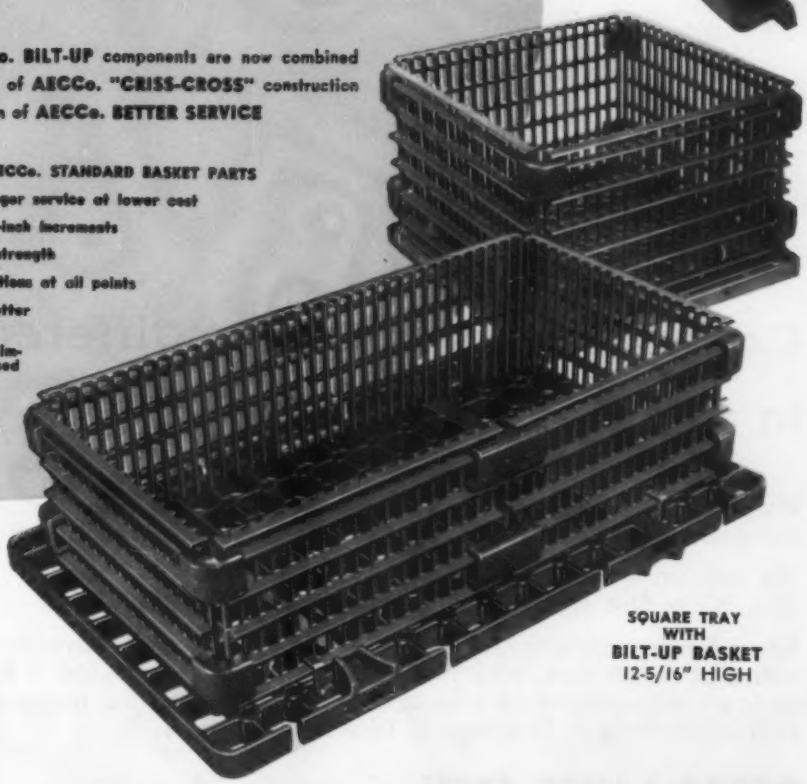

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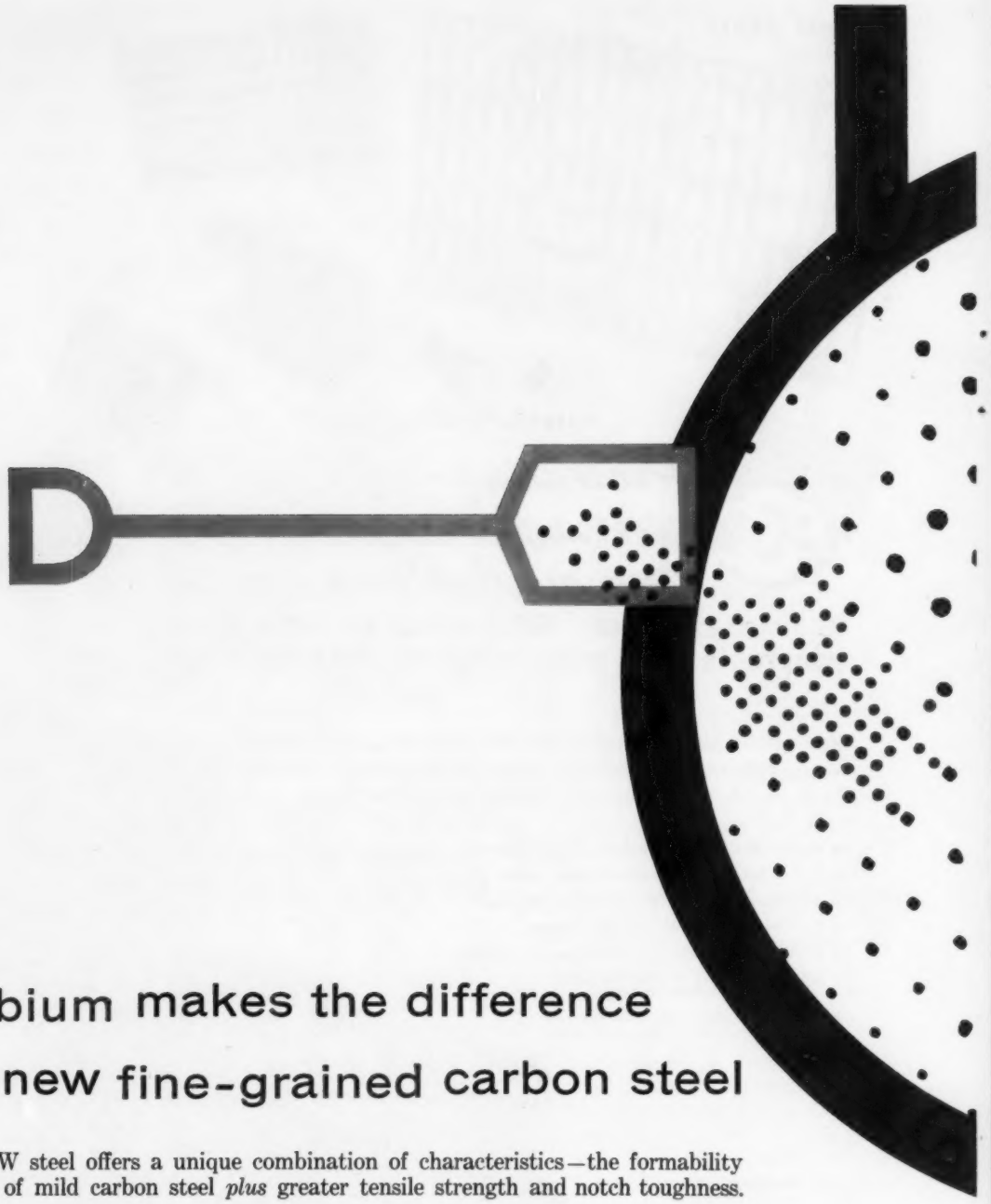

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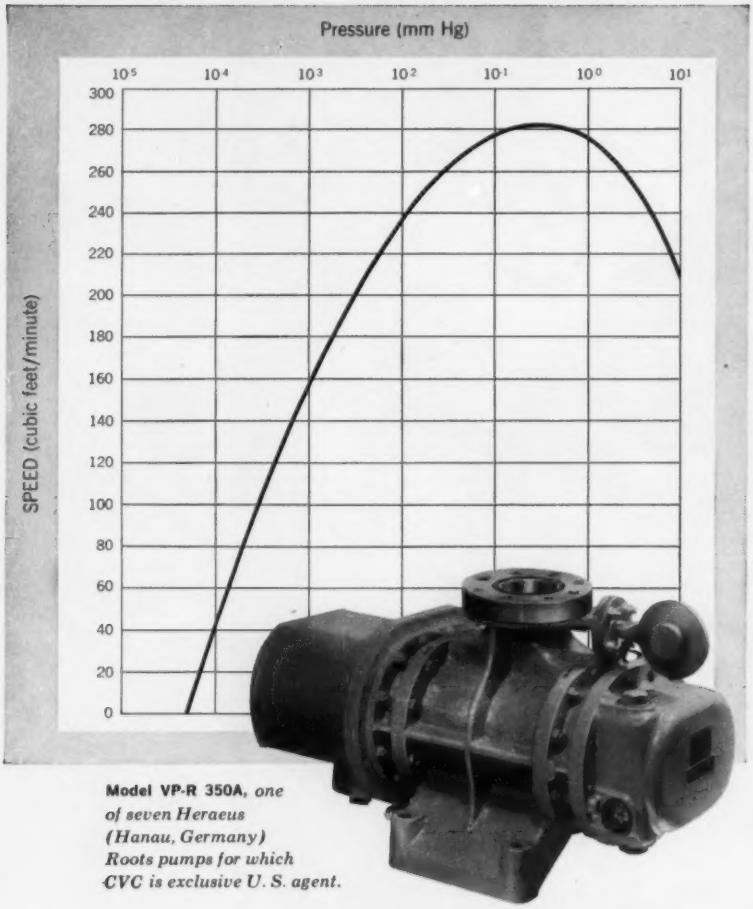
GLX-W

Circle 506 on Page 48-A



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Circle 535 on Page 48-A

Weld Porosity . . .

shielded consumable electrode process with matching filler wire was used for these tests. For hydrogen, a special torch was used in the welding operation.

Test Results – Nitrogen led to the severest porosity level of any gas in high-nickel alloy welds, threshold porosity appearing at 0.2% nitrogen and becoming severe at 1%. For mild steel, the threshold level of porosity was at about 5% nitrogen. The electric arc process may be more susceptible to nitrogen porosity than the other processes.

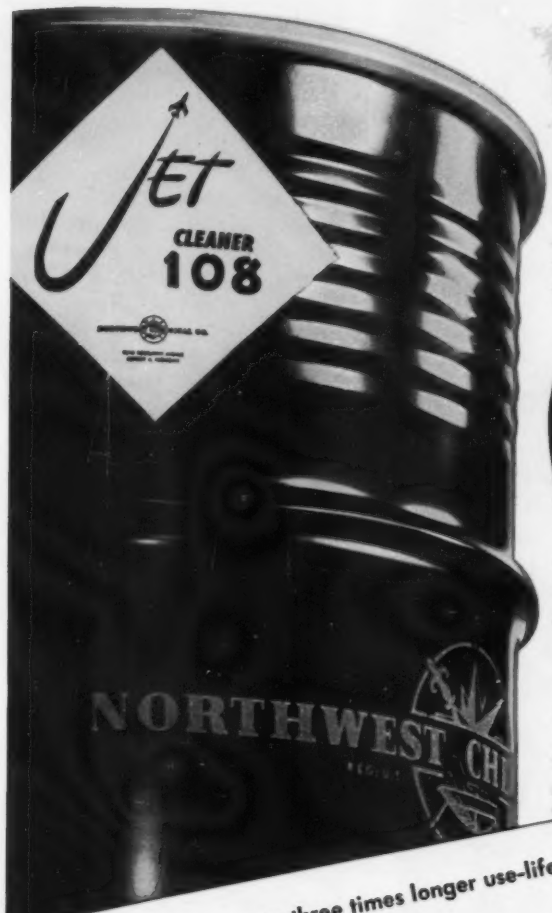
For carbon monoxide, the threshold level of porosity for pure nickel and Monel is at 4 to 5%, becoming severe at 7 to 10%. The stainless steels, Inconel and mild steel were unaffected by up to 10% carbon monoxide in the shielding gas. Metal-arc welds may be more susceptible to this type of porosity.

For oxygen, porosity in nickel and Monel develops initially at the 4 to 5% level, becoming nearly as severe as carbon monoxide porosity at the 10% level; mild steel is also porous at this level. Chromium bearing welds were sound. Oxygen-bearing argon should not be used for high-nickel alloy welds because critical elements are lost, and oxide films deleterious to multipass welds form.

Hydrogen actually enhanced the soundness of welds in nickel-base alloys when low-purity shielding gas and low travel speeds were used, the optimum level being 10 to 25% hydrogen. This is unnecessary with today's 99.9% purity helium. Other workers found no adverse effects.

Carbon dioxide as a gas shield leads to heavy spatter, loss of deoxidizers and other elements from high-nickel alloy welds, and gas porosity. A heavy oxide residue is formed on the weld surface of chromium, titanium and aluminum bearing alloys, which is deleterious in multipass welds. Inconel welds were least affected but still substandard.

Porosity inducing gases can be excluded from the arc by exact control of arc length at 0.050 in. in the automatic tungsten arc process. However, deoxidizers and gas fixing elements must be present when welding high-nickel alloys with coated electrodes by manual tung-



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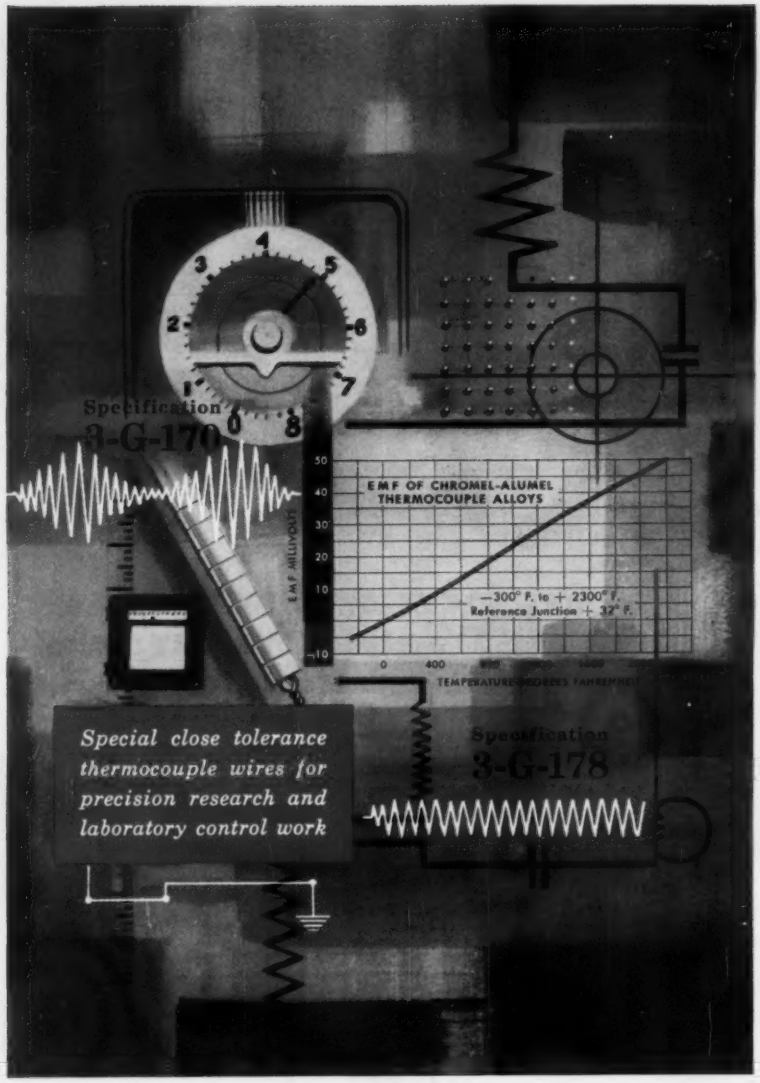

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Circle 536 on Page 48-A

Weld Porosity . . .

sten arc welding and inert-gas consumable electrode welding. Drafts must be avoided and fluxes kept dry.

To be on the safe side, gas fixing additions should be made to filler wires in all processes. Titanium is eminently suitable because of its high affinity for oxygen, nitrogen and carbon. It is supplemented by manganese, aluminum and silicon. Filler wires are specific to one process and are not interchangeable. A "dry box" or inert-gas-filled chamber is not required in welding high-nickel alloys.

P. D. BLAKE

Fatigue Testing in High-Temperature Controlled Environment

Digest of "A High-Temperature, Vacuum, and Controlled Environment Fatigue Tester", by G. J. Danek, Jr., and M. R. Achter, A.S.T.M. Preprint No. 73, 1958.

INCREASING USAGE of materials under cyclic, high-strain loading at elevated temperatures has stimulated interest in studies of such loading. Since no commercial equipment was available, the U.S. Naval Research Laboratory designed and built a suitable machine.

A cantilever, sheet-type specimen is mounted in a vacuum chamber enclosed in a split-type resistance furnace. Motion is transmitted through magnetic coupling to maximize vacuum tightness. The specimen is vibrated at resonant frequency by two mechanically driven oscillating magnets on the outside of the furnace, or by two electromagnets which are alternately excited. The mechanical system is simple and easily constructed but requires periodic adjustment. The electromagnet system is more complicated but gives more accurate and convenient control over vibration and is considered better suited for long term tests.

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Circle 508 on Page 48-A

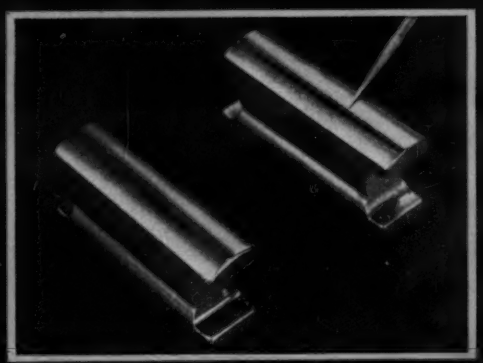
High Carbon Steel

wears almost III times longer when

CHROMALLIZED

HERE IS POSITIVE PROOF

In a test conducted by the Formsprag Company of Warren, Michigan, CHROMALLIZED sprags were removed from an automobile transmission after 55,000 miles of use and compared with ordinary sprags from another transmission after 33,000 miles of use. The CHROMALLIZED sprags showed less than half the wear of the other sprags.



Chromallized sprag (left) shows almost no wear, while an ordinary sprag shows considerable wear.

WHAT IS CHROMALLIZING?

A proven process of diffusing Chromium with other elements into the surface provides an alloy case which is integral with the base metal. It can't peel or flake; the chromium and other elements diffuse uniformly into recesses, pores, cracks and even blind holes. CHROMALLIZING provides not only resistance to wear but also considerable resistance to corrosion and oxidation.

This process may be applied to superalloys and refractory metals for high temperature oxidation resistance.

WRITE FOR ILLUSTRATED BULLETIN

Chromalloy corporation

450 Tarrytown Road • White Plains, New York
WHite Plains 6-0020

CHROMIZING CORPORATION, LOS ANGELES, CALIFORNIA
PROPELLEX CHEMICAL DIVISION, EDWARDSVILLE, ILLINOIS
Propellents, cartridge actuated devices, explosives and special chemicals.
ELYRIA FOUNDRY DIVISION, ELYRIA, OHIO. Quality gray iron castings.
SINTERCAST DIVISION, YONKERS, N. Y. Machinable carbides & nuclear materials.

Circle 537 on Page 48-A

Fatigue Testing . . .

All required quantities can be measured directly except the effective mass of the specimen and coupling rod. The simplest procedure for determing this quantity appears to involve successive trials at five frequencies. This, in turn, requires a series of calibration curves for each temperature and material used. This method, however, does eliminate the need to know the elastic moduli at elevated temperature and the temperature gradient along the specimen. Despite the effort required to determine stress, all sources of uncertainty result in a maximum error of 1.3% in calculated stress.

The test equipment, as constructed, can be used for both environment studies and, under vacuum, for investigation of fatigue damage, crack initiation, and crack growth at elevated temperatures.

C. O. SMITH

Treating of Molten Aluminum

Digest of "Chemical Treatment of Molten Aluminum and Aluminum Alloys", by H. Eisenreich, and M. G. Neu, *Aluminium* (Germany), March 1959, p. 131-135.

CHEMICAL TREATMENT of the melt imparts certain qualities to the finished casting or ingot. The melt is affected by temperature, rate of cooling, percentage of alloys and impurities, their distribution in the melt, their chemical reaction and the effect of temperature changes on this reaction.

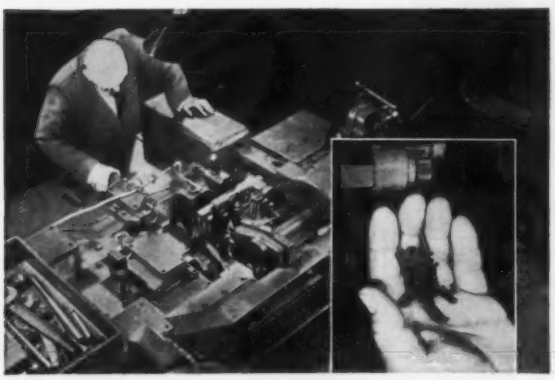
For a good melt, the charge must be perfectly pure and dry, and melt rapidly. The mixture must also be heated to the required maximum temperature rapidly, and should be protected against absorption of oxygen and hydrogen from furnace gases and the atmosphere. Under normal operating conditions, coarse dross quickly floats to the surface, but fine, suspended oxides take a long time to settle and will do so only if the melt level in the pot is low and if there is no agitation. (In practice, it is almost impossible to meet these requirements in induction furnaces or melting pots.) Hydro-

Which picture do you fit?

Here are four *actual* customers* with different, but exacting product and technical needs. One uses Bridgeport rod in a range of alloys, the second Bridgeport strip. A third makes fasteners from Bridgeport Brass wire. The fourth company uses Bridgeport condenser tubes *and* Technical Service to produce quality heat exchangers. Which picture do you fit with your raw materials and manufacturing requirements?

"AUTOMATIC QUALITY," says Customer A. "We've a high-volume, automatic screw machine operation. Our alloy needs vary from job to job. Our production schedules demand *consistent* quality alloy and accurate gauge. With every rod alloy we get from Bridgeport, we get what we order . . . including aluminum alloys!"

"LONG-LENGTH COILS. They're one reason why we can depend on Bridgeport for strip," says Customer B. "Superior surface finish from Bridgeport saves us production costs. With their Sendzimir mill finish and exact gauge and width in long-length coil, you can see the reasons why we depend on Bridgeport for brass, copper and aluminum strip."



"CONSISTENT GAUGE. We need Bridgeport quality brass wire to make thousands and thousands of fasteners of every description," says Customer C. "High-speed, volume cold-heading production is only as good as the alloy wire that's used. Bridgeport Brass wire is made to exact tolerances for cold-heading at high speeds—we depend on it."

"PRODUCT PLUS SERVICE," says Customer D. "We manufacture heat exchangers for many applications. Our requirements include good technical and engineering service as well as a wide choice of brass, copper and aluminum tube alloys. All of these are available from Bridgeport."

*Names on request

These examples typify national metalworking opinions. There's no mystery why manufacturers the country over depend on Bridgeport—Bridgeport products and service are *close at hand*. The many brass, copper and aluminum alloys made by Bridgeport in rod, tube, wire and strip are *readily* available from stocks in your area; Bridgeport warehouses are located to make it easy for you to get what you want on time. Volume needs are mill-delivered. Your call to your nearest Bridgeport Sales Office, or a letter to Dept. 4101 will get you engineering and technical service. Try it, and you'll agree —you do fit into the picture!

Bridgeport Brass Co.

BRIDGEPORT BRASS COMPANY

Bridgeport 2, Conn. • Sales Offices in Principal Cities

Specialists in Metals from Aluminum to Zirconium

Circle 589 on Page 48-A

Molten Aluminum . . .

gen is either dissolved in the melt or trapped in the form of hydrogen compounds. The melt lacks nucleating agents, and is covered with a skin of dross.

Degassing and Purification

The most commonly used fluxing agent is chlorine. It reacts quantitatively with the melt, forming aluminum chloride. The gas must not be introduced in the melt at too fast a rate and it has to be evenly distributed in it. The quantity varies from 0.15 to 0.6%. Disadvantages are: grain coarsening, material losses of aluminum and magnesium (if the melt also contains this element), difficulties in proper handling of the chlorinating equipment. This has led to the use of carbon compounds which generate chlorine in the melt, instead of gaseous chlorine. Gases from these compounds form smaller bubbles which are more effective. Hexachloroethane – one of these compounds – develops about 30% chlorine at a working temperature of 1400° F. The rest of the chlorine forms carbon chlorides which appear to give better gas absorption and purification than the aluminum and magnesium chlorides formed by gaseous chlorine.

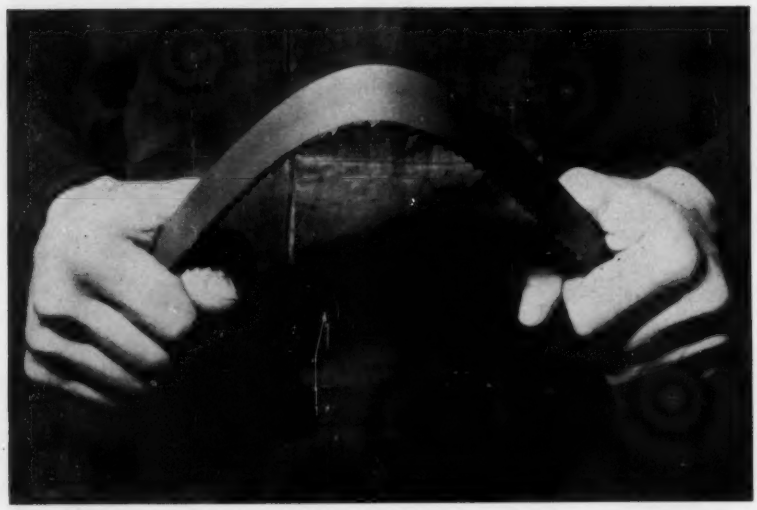
A degassing agent was recently developed, in which carbon chloride is compressed in a porous base material. This evenly distributes the gases released by the reaction and thereby improves their effectiveness. Carbon chloride compounds do not destroy nucleating agents as elementary chlorine does, because the quantities of pure chlorine released by the reaction are smaller. Any desired quantity of grain refiner can be added to the carbon chloride for grain refinement.

Grain Refining Practice

The formation of nuclei is essential for grain refining. The following materials give good results as nucleating agents: TiB_2, AlB_2, TiC. Another good type of grain refiner is based on alkaline titanium fluoride and hexachloroethane. Temperature changes affect their reaction only slightly. The most favorable combination for grain refiners is, however, the one which contains alkaline boron fluoride also. For best results, the temperature should not fall below 1380° F. because boron does not mix well with molten metal at lower temperatures.

A special instance is the refining of eutectic and slightly hypo-eutetic aluminum-silicon alloys with sodium. The refining process does not affect the size of the primary aluminum crystals, but it gives a smooth, uniform texture to the eutetic alloy. The causes of this refinement have not yet been fully explained, but it is known that the addition of sodium (and of several other alkaline and alkaline earth metals) lowers the temperature.

The metallic sodium formerly used has been replaced with mixtures of sodium salts which are melted by the liquid metal and quickly absorbed in the melt. Recently, another process for adding sodium to the melt has been perfected. Vacuum distilled sodium is stored in vacuum aluminum tubes, which are also used to add the sodium to the melt. This speeds up the process at



THIS is No Ordinary Power Hack Saw Blade

This is the *unbreakable* MARVEL High-Speed-Edge Hack Saw Blade —the first bi-metal blade—invented, developed and introduced by MARVEL. This blade is a combination of two materials best suited to the requirements of an efficient hack saw blade . . . a narrow high speed steel cutting edge permanently welded to a tough, non-brittle alloy steel body. Each blade is triple tempered to assure long life and maximum toughness to the cutting edge.

With a MARVEL Blade, you can cut any material—from the free machining steels to the toughest alloys . . . fast, accurately and economically. You can tension a MARVEL Blade from 200% to 300% tauter than any ordinary blade, permitting much higher speeds and heavier feeds without deflection or breakage.

Like all good things, attempted copies of the MARVEL Blade have been numerous, but its performance has been *unequalled* by any of the imitators. Ask for MARVEL Blades by name and you can be sure you're getting the best on the market. Leading Industrial Distributors have them in stock.

Write for latest cutting tool Bulletin and the name of your nearest MARVEL *Distributor.* FB-1020

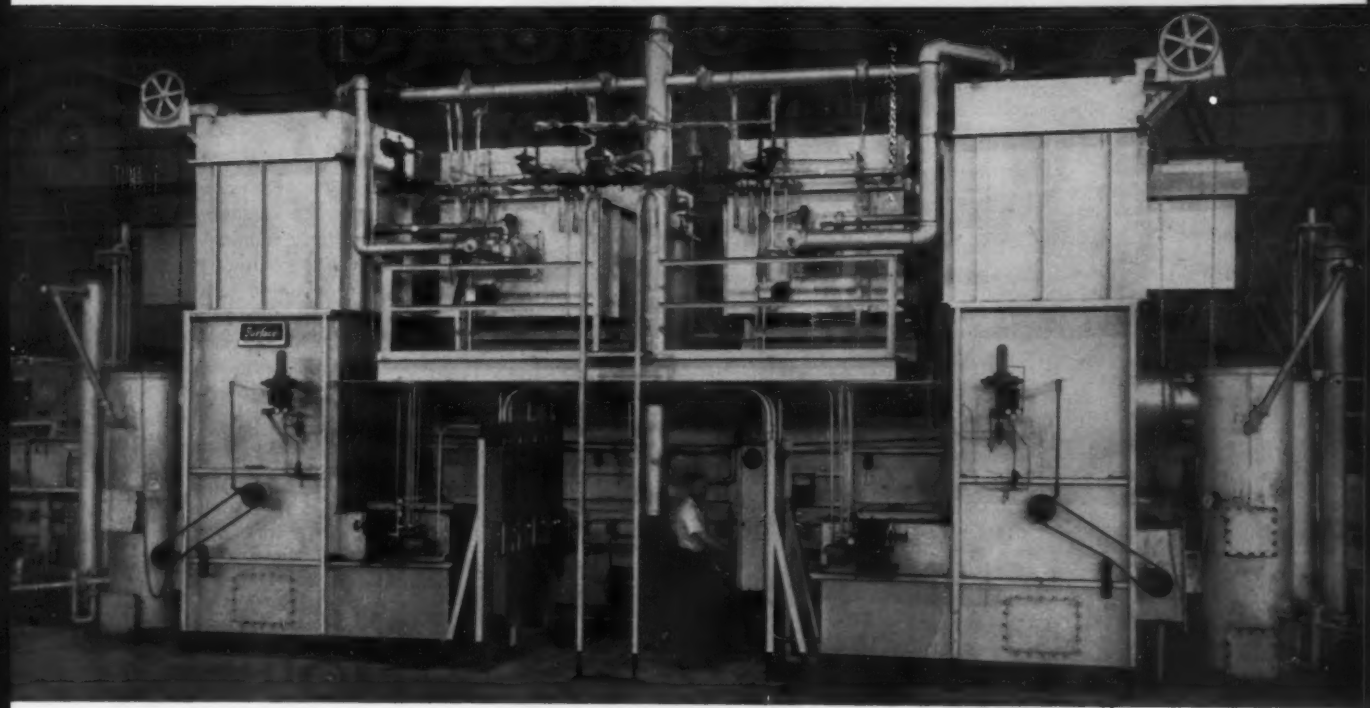
MMT-PE

MARVEL Metal Cutting SAWS

Better Machines-Better Blades

ARMSTRONG-BLUM MFG. CO. 5700 W. Bloomingdale Ave., CHICAGO 39, U.S.A.

Circle 538 on Page 48-A



SURFACE POWER CONVECTION

speeds annealing rate to 8,000 lbs/hr of brass tubing

This furnace is one of Scovill Manufacturing Company's (Waterbury, Connecticut) answers to the threat of imported brass and copper mill products.

Scovill is after new highs in production and quality in its new streamlined tube mill at New Milford, Conn. This continuous roller hearth furnace, equipped with Surface Power Convection, helps achieve both goals. It anneals and cools 8,000 lbs. of brass and cupro-nickel tubing an hour. At the same time, it produces tubing of superior physical properties because it maintains temperature uniformity at plus-minus 8° F.

Such process speeds and temperature uniformity are possible only with Surface Power Convection, the most important advance in convection heat transfer in 20 years. Ask your Surface representative how you can apply this profitable new technology to your products. Write for Bulletin SC-182.

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A DIVISION OF MIDLAND-ROSS CORPORATION

In Canada: Surface Industrial Furnaces, Ltd., Toronto, Ontario

Surface

wherever heat is used in industry

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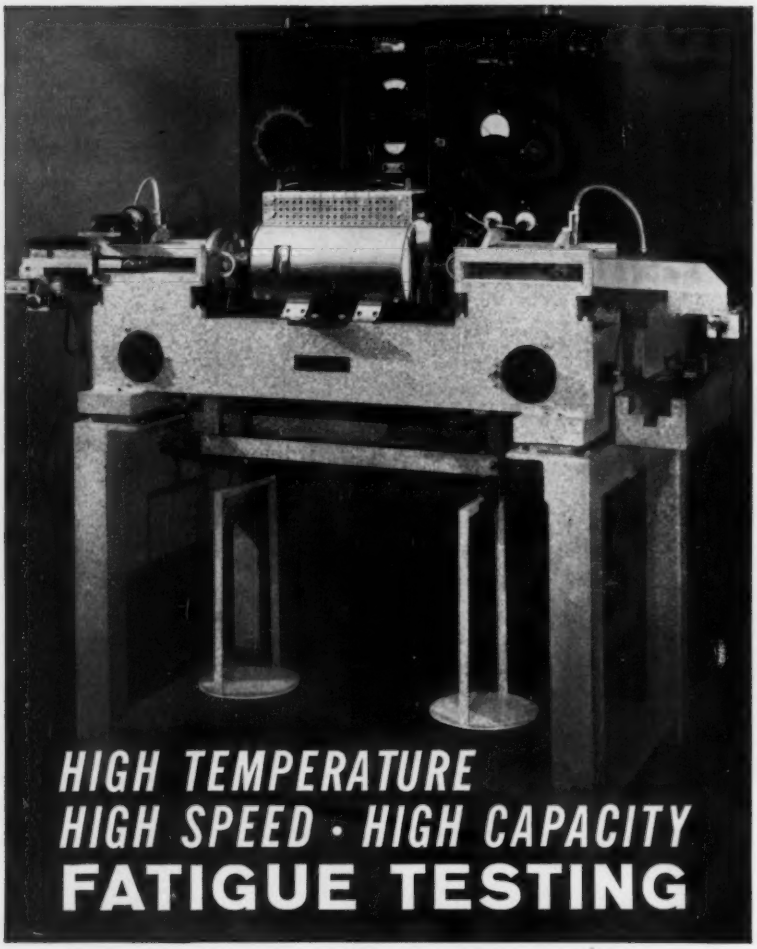

with the new 850 in.-lb. Rotating Beam Machine from Budd

Designed for testing new heat-resistant materials used in jet engine, rocket and missile programs, this new Tatnall-Krouse machine provides unsurpassed performance for your most critical applications. It has a bending moment capacity of 850 inch-pounds . . . speeds from 3,000 to 12,000 cycles per minute . . . temperatures from 200 to 1800°F. ±3°. It takes specimens 4 to 8 inches long, and 16 to 20 inches long.

For details, write or call for Bulletin BM-2050.

Other Budd testing equipment includes Tatnall creep testing machines and tensile testing machines, and Tatnall-Krouse variable speed plate machines, constant speed sheet machines, and other rotating beam machines. We will be glad to help you evaluate your testing requirements and select the right equipment.

INSTRUMENTS Budd DIVISION P.O. Box 245 • Phoenixville, Pa.

Consult your phone book for sales offices in: Atlanta, Ga., Oak Park, Ill., Dallas, Tex., Los Angeles, Calif., San Francisco, Calif.
In Canada
Tatnall Measuring and Nuclear Systems, Ltd., 46 Hollinger Rd., Toronto 16, Ont.

Circle 539 on Page 48-A

Molten Aluminum

lower working temperatures, and reduces gas absorption and pitting of the pot.

Dross Separation

Solid fluxes prevent oxidation of the metal as far as possible, remove oxides trapped in the melt and promote the fusing of metal particles during melting. Many researchers believe that the added fluxes actually dissolve the aluminum oxide film on the metal surface. While it is true that aluminum oxide is soluble under high temperature in salts (such as cryolite and fluorite), the temperatures used for melting aluminum are too low to dissolve any appreciable quantities of aluminum oxide. Actually, the flux probably removes the oxide film by surface forces. Such a process is in many respects similar to the removal of oxide films from iron during pickling.

The separation of metal from metal oxide caused by the above described reaction does not necessarily mean that all the separated metal will drain from the dross into the melt. The dross contains frequently as much as 50 to 75% aluminum with a grain size of 10 to 75 microns. Failure to recover this aluminum may result in substantial losses. For this reason, fluxes containing fluoride have been developed, which cause the aluminum particles to flow together and separate from the dross.

K. C. SPENCER

Impact Fatigue

Digest of "Impact Fatigue Resistance of Structural Steels", by B. N. Das and G. D. Sani, *Transactions*, Indian Institute of Metals, Vol. 10, 1956-57, p. 103-118.

THIS PAPER calls attention to the little studied phenomenon of impact fatigue. Engineering parts such as ends of rail joints, shafts of pneumatic hammers or parts of internal combustion engines undergo repeated impact stressing in service. In choosing material for applications requiring impact fatigue resistance, the engineer must presently rely on comparison between fatigue test results (S-N curves) of different

METALGRAMS

. . . news about metals and metal chemicals

UNION CARBIDE METALS

Electromet brand ferroalloys, pure metals and metal chemicals

JANUARY - FEBRUARY, 1960

Using arc-melted "Electromet" columbium, The Ladish Company, Cudahy, Wis., has successfully forged a Cb-0.75% Zr ring, measuring 7¾ in. O.D. x 6 in. I.D. x ⅞ in. thick. The ring was made during a co-operative experimental program in which Union Carbide Metals supplied the columbium in the form of an alloyed ingot. An objective of this program was to demonstrate the forgeability of a columbium alloy of "commercial" purity. Much of the work to date has been based on ultra-high purity material. General data on columbium can be found in Bulletin CB2-P5.

* * *

Ferric acetylacetonate is going into semicommercial production at Union Carbide Metals. This "Electromet" metal chemical and other acetylacetonate derivatives of the transition metals (e.g., Cr, Co, Mo, Mn, V, and Ni) offer a convenient means of putting the metals in solution in organic systems. They are chelated, non-ionizing compounds, and slightly soluble in water. They form solutions which are neutral and resistant to hydrolysis. The acetylacetonates are available as pure, crystalline powders. Bulletin AA1-.5 gives property data.

* * *

Vanadium sheet -- wider than previously available -- has been produced by Union Carbide Metals Company. The sheet, measuring 19½ in. wide by 40½ in. long by 0.065 in. thick, is a new development in vanadium technology. Formerly requests for widths greater than 6 in. had not been made. Should the demand arise, wider sheet can be produced without difficulty. The high degree of workability observed during this wide-sheet production reflects the improved purity of the Company's vanadium metal. Several wire sizes are also available from stock. Union Carbide Metals offers melting stock for sale and will supply custom quantities of a range of vanadium mill products. Request Bulletin VM1-P5 for general information on vanadium.

* * *

The outstanding oxidation and corrosion resistance of chromium carbide can now be utilized on pre-formed base materials. Coating techniques such as flame-spraying and electrodeposition, currently under study, are extending the applicability of this refractory compound. New areas include coatings for such components as turbine blades, while established uses are in shapes fabricated by powder metallurgy techniques. Union Carbide Metals' field representatives are discussing chromium carbide powder and its application with users of oxidation- and corrosion-resistant coatings. Bulletin CC1-P5 gives general data on chromium carbide.

* * *

Oxidation-resistant coatings for columbium and its alloys are another area of research at Union Carbide Metals. A duplex coating, which is among those being studied, performed satisfactorily above 2000°F. during preliminary tests. The Company's field representatives are available to exchange information on coatings, their applications, and related problems. For laboratory performance data, ask for AC1-P5.

* * *

Union Carbide Metals Company, Division of Union Carbide Corporation, P. O. Box 330, Niagara Falls, N. Y. In Canada: Union Carbide Canada Limited, Toronto.

The terms "Electromet" and "Union Carbide" are registered trade marks of Union Carbide Corporation

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Chace Thermostatic Bimetal

ACTUATES ANOTHER PRECISION PRODUCT

A PRODUCT OF AMERICAN-STANDARD
DETROIT CONTROLS DIVISION, DETROIT, MICHIGAN

This new thermostat, No. CA 520, a product of American-Standard, Detroit Controls Division, offers the ultimate in style, comfort and dependability. It was designed and manufactured especially for use with American-Standard Furnaces, the "one responsibility" concept. Its features include: hermetically sealed mercury switch; soldered circuit joints and flexible wire; clear plastic base plate for fast installation; five-degree dial calibration and wider selection of temperatures (50° to 90°); and attractive decorator design with concave rim and cover, in bronze and silver, (or paint it yourself). Both the actuating element and the temperature indicating element are Chace Thermostatic Bimetal.

Perhaps sensitivity (or lack of it) is the one feature of a room thermostat most likely to impress the homeowner. One wants to be unconscious of a heating system, not reminded by frequent periods of chill or overheating. The extreme sensitivity and unfailing reliability of Chace Bimetal are the result of Chace's third-of-a-century devoted to the development of efficient alloys and bimetal combinations, plus manufacturing methods and equipment devoted exclusively to the production of precision thermostatic bimetal. Discriminating bimetal buyers can always be certain that their names on the "outside" are safe with Chace "inside."

Chace Thermostatic Bimetal is available in strips, coils and completely fabricated elements of customers' designs — and in more than 30 types. If you have a product in the "thinking stage," send for our booklet, "Successful Applications of Chace Thermostatic Bimetal," for its many pages of illustrated temperature-actuated devices plus much valuable engineering data.

IT BENDS WITH THE HEAT

W. M. CHACE CO.
Thermostatic Bimetal
1626 BEARD AVE., DETROIT 9, MICH.

Circle 540 on Page 48-A

Impact Fatigue . . .

materials. Or he may compare impact energy curves and try to evaluate what the energy levels of these curves at different temperatures really mean in terms of the intended application. He may have found, for example, that a certain steel could be recommended when based on the endurance limit of the S-N curves, but would be unsuitable when impact test data are considered as criterion. Practically no quantitative data are available in the technical literature that can provide the engineer with information as to the impact fatigue resistance itself.

The present investigation provides some quantitative information on the impact fatigue resistance of five structural steels. Standard rotating beam fatigue specimens and the specially designed impact fatigue specimens were machined from ⅞-in. diameter rolled bar in the normalized condition. The fatigue specimens were finished by manual polishing in the longitudinal direction.

The impact fatigue specimens were tested in an Amsler Universal Hammer Machine where the specimen was exposed to 650 external blows per min. while rotating similar to a standard fatigue test. The specimen can be considered as a simple supported rotating beam, receiving about 100 blows per revolution.

To establish the actual stress in the outer fiber of the specimens, calibration tests were performed during which the stress was measured statically and dynamically by means of SR-4 gages. In the static test a curve was established giving the relation between maximum fiber stress and load at the center of the span. In the dynamic test a similar curve was found in relation to the kinetic energies of the adjustable blows. From these two curves an equivalent load can be found for any chosen kinetic energy of blow. It is thus possible to plot standard fatigue data and impact fatigue data on the same S-N diagram. In the former, the conventional maximum stress versus log of number of cycles-to-failure is plotted, while in the latter, the equivalent stress is plotted against the log of number of blows-to-failure. In all five cases, the impact endurance limit is about 85% of the

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Remember, there's an ISOBRITE Brightener especially designed for your specific operations—whether you're rack or barrel plating zinc, cadmium, copper or white brass . . . an ISOBRITE Brightener that is entirely compatible with most other brighteners. Don't just order brighteners—specify ISOBRITE. There *is* a difference!

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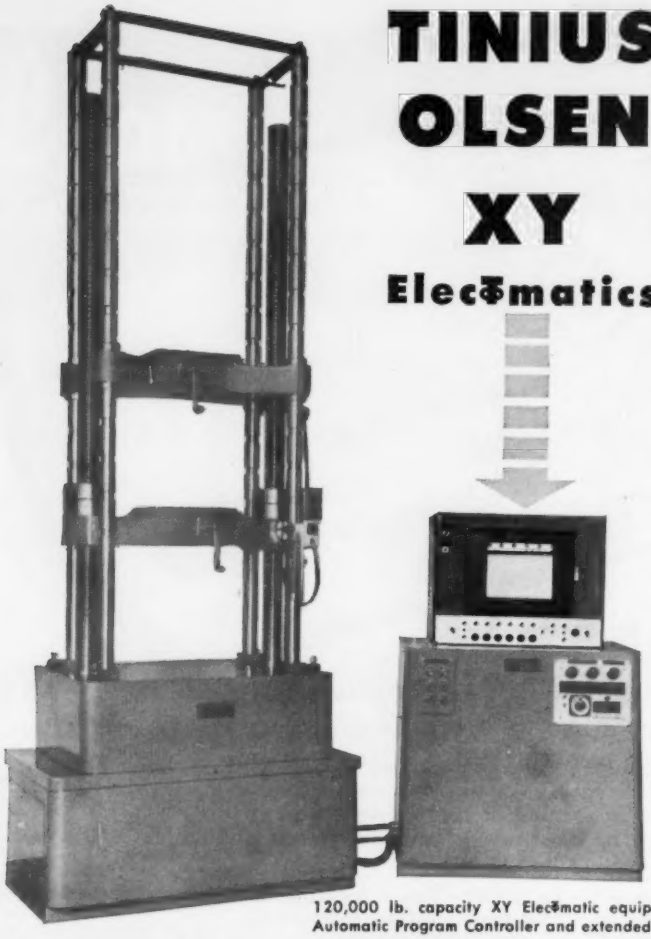
Circle 510 on Page 48-A

TINIUS OLSEN XY Elec∓matics



120,000 lb. capacity XY Elec∓matic equipped with Automatic Program Controller and extended columns.

HAVE NO CAPACITY LIMIT

Originally conceived for testing such low tensile materials as plastic films, fibers, etc., the inherent versatility of Tinius Olsen XY Elec∓matics to 12,000 lbs. has sparked a demand for higher capacity models. Testing engineers throughout industry have grasped the unmatched advantages of the Olsen XY strip chart recorder and the wide variety of testing functions this machine performs.

A minimum of eight testing ranges of as little as 1/200 capacity are built into the machine and are available at any time with the flip of the range selector switches. Any testing speed may be dialed and held constant under load by the variable speed motor drive. Testing stroke is unlimited.

Coupled with Olsen strain instrumentation, accurate stress-strain curves can be made for any material, no matter how fragile. Automatic program controls further extend the variety of vital testing procedures, including stress, strain or crosshead cycling.

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Testing and Balancing Machines

Circle 541 on Page 48-A

Impact Fatigue . . .

conventional endurance limit. In other words, the impact fatigue test rates the several steels quantitatively in the same order as the conventional fatigue test does. This is not true when impact fatigue is compared to conventional single-blow impact test.

The difference in the two types of fatigue tests is best shown by considering the stress history of a single outer fiber of the specimen. In the rotating beam fatigue specimen the stress varies sinusoidally; from a maximum in tension through zero to a maximum compression and back through zero to a maximum in tension per revolution. In the impact fatigue specimen this sine curve represents the envelope to 100 stress peaks, one for each blow, which, therefore, vary in magnitude and direction (tension-compression) as the specimen rotates. Thus, tensile or compression peak stresses are attained only once in each 100 blows. It may, therefore, be expected that when the peak stresses are applied 10 million times as is usual in fatigue tests, the impact endurance limit will be still lower. A few tests, in which the specimen was rotated 180° after each blow, have verified this assumption. Further work is in progress. F. FORSCHER

Future Heat Treating in Russia

Digest of "Direction of Future Developments in the Heat Treatment of Metals", *Metallovedenie i Termicheskaia Obrabotka*, No. 5, 1959, p. 2-6.

THE CURRENT seven-year plan of U.S.S.R. economic development devotes considerable attention to progress in machine building, particularly heavy machinery. Anticipated sharp increases in production of machine tools, automobiles and tractors, development in the aircraft industry, and unprecedented growth of measuring and metalcutting tool production will require large mechanical working and heat treating capacity.

Hardening, tempering, annealing, chemical-thermal treatment, forging and forming are some of the proc-

90 seconds of inferno

A rocket engine capable of more than 50,000 lbs. of static thrust, developed and built by Reaction Motors Division of Thiokol Chemical Corporation, will soon send the fabulous X-15 searing into outer space. To protect the engine from its own fierce blast, key metal surfaces are coated with ROKIDE "Z" coating.

...but ROKIDE* Coating will protect the X-15's engine during critical burning time

As the manned X-15 bores into the sky for 100 miles or more in its forthcoming tests, rocket-powered flight will last only for about a minute and a half. However, protecting the engine from the tremendous heat and erosive force of its propellants for even that brief span posed a major design problem. Engineers solved it by coating critical metal surfaces with ROKIDE "Z" zirconium oxide — one of today's most rugged refractory materials.

This is typical of the new and challenging requirements which all three types of hard, crystalline ROKIDE spray coatings ("A", "ZS" and "Z") are meeting in the ever-expanding air and space programs. These outstanding members of Norton Company's large family of refractory materials, as well as other experimental coatings such as chrome oxide, spinel, etc., are providing protection against high heat and abrasion, corrosion and severe thermal shock in supersonic aircraft, missiles and rockets.

Norton Company maintains ROKIDE coating facilities on both coasts: at the main plant in Worcester, Mass., and at its plant in Santa Clara, California. For details, write NORTON COMPANY, Refractories Division, 321 New Bond St., Worcester 6, Massachusetts.

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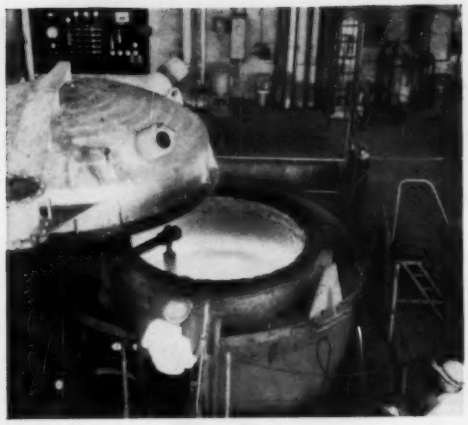

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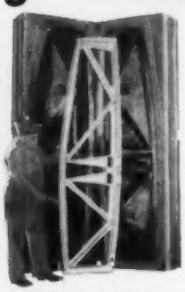
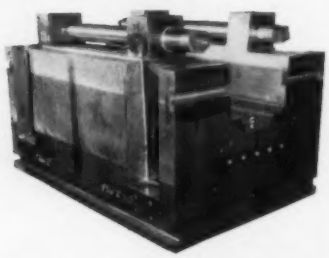


Two 15,800 pound Finkl dies for precision aircraft forgings



36,000 pound die holder for use in titanium production, completely machined by Finkl

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Circle 542 on Page 48-A

Heat Treating . . .

esses which consume large amounts of energy. Improvements in these processes are designed to decrease energy consumption wherever practicable, and to permit production line heat treating.

At the present time, frequencies of 50, 2500 to 10,000 and 70,000 to 1,000,000 are used in induction heating for heat treatment, forging, forming, rolling, bending, cutting and knurling, in connection with welding and overlaying, in casting production, and other processes. From 1959 to 1965 heavy machine building plants will develop applications of induction heating for surface hardening of large and complex parts, for localized heating in heat treatment of carbon and alloy steel weldments, and for general and local heating of billets prior to hot working.

Special attention will be paid to development of methods to improve the surface mechanical properties of large and complex parts such as gears, crankshafts, and similar items. The Likhachev Automobile Factory and Central Research Institute for Ferrous Metallurgy in Moscow are developing new shallow hardening steel compositions.

In deep hardening of gear teeth, high hardness is usually imparted to the outer layer. The new steels will achieve sufficient hardness at the periphery, and will be relatively deep hardening in complex parts.

The electroslag welding method permits substitution of weldments for large forgings and castings. Local induction heating of electroslag weldments will improve the microstructure in the weld area, decrease distortion, and eliminate straightening operations, and shorten the thermal treatment cycles. An important advantage of new technology is the possibility of local heat treatment without removing the workpiece from the welding area.

Wide uses of induction heating are expected in connection with other welding and hard surface methods. Welding of power generative machinery parts of large thickness will require 575° F. preheat in the welded zone areas. Induction heating, which generates heat within the part, seems more advantageous than multiple gas

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Circle 512 on Page 48-A

Heat Treating . . .

torch or electric muffle furnace for this work.

In forging and forming, efforts will be directed toward decreasing the billet or blank heating time, and reducing metal losses due to overheating. Recent work has shown that the heating rates can be considerably increased and that rapid induction heating is very effective for this purpose. This is of particular importance in working high-alloy steels and heat resistant alloys. Research has shown that rapid heating, which permits a higher upper limit of the forging range, results in the considerable decrease (up to 40%) in deformation effort required in hot working. This also often eliminates intermediate reheatings in working very large ingots. Induction heating has been found to be particularly effective in heating blanks for shaping in automatic or semi-automatic machines, in gear teeth forming, tube bending, ring rolling, and expanding, groove forming, and the like. The number of factories (such as the Moscow Small Automobile Plant and Gorky Automobile Factory) which use induction as their sole heating method for forging and forming is expected to increase.

The uses of chemical-thermal treatment are expected to increase. One of these is the newly developed gas hardening method with prior induction heating. A typical installation for case hardening, combined with isothermal hardening, is used by the Likhachev Automobile Factory for case hardening gear teeth. It case hardens gears at a rate of 650 lb. per hr. The installation performs the following operations: nitriding or carburizing, isothermal hardening, removal of salt or oil from case hardened gears, and low-temperature tempering. It takes 45 min. to achieve a hardened layer instead of the usual 8 hr. Gas temperature and composition in the hardening chamber are automatically controlled. Loading, moving, and unloading of parts is automatic, and the operator merely starts loading of gears and observes the control instruments. Such installations will contribute to development of complex automatic production lines and improve working conditions.

Savings are expected when the heat treating operations are shifted from machine building plants to the rolling mills. Cost of these operations, performed by heating installations placed in the rolling mill production lines, is expected to be much lower than hardening and tempering performed at the machine building plants. Similarly, it will be economical to heat treat immediately after forging or forming. Proper thermal-mechanical cycle in hot working will permit quenching from the forging temperature, eliminating the subsequent heating for hardening.

Of economic importance in thermal treatment of large components is rapid heating for hardening and tempering by placing parts into hot furnaces. A method of "self-tempering" after surface hardening of steel parts, investigated at the Likhachev Auto Factory, is based upon strictly controlled length and rate of cooling after hardening. The heat remain-

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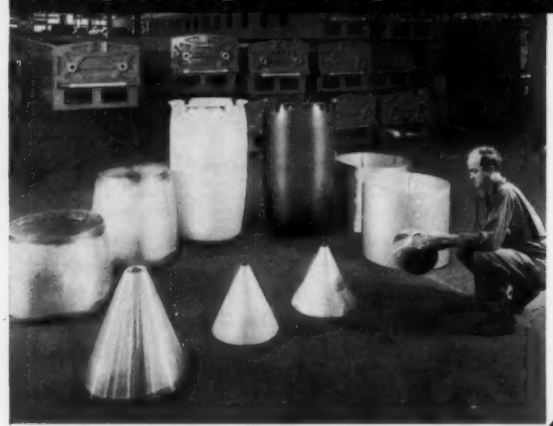

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Circle 543 on Page 48-A

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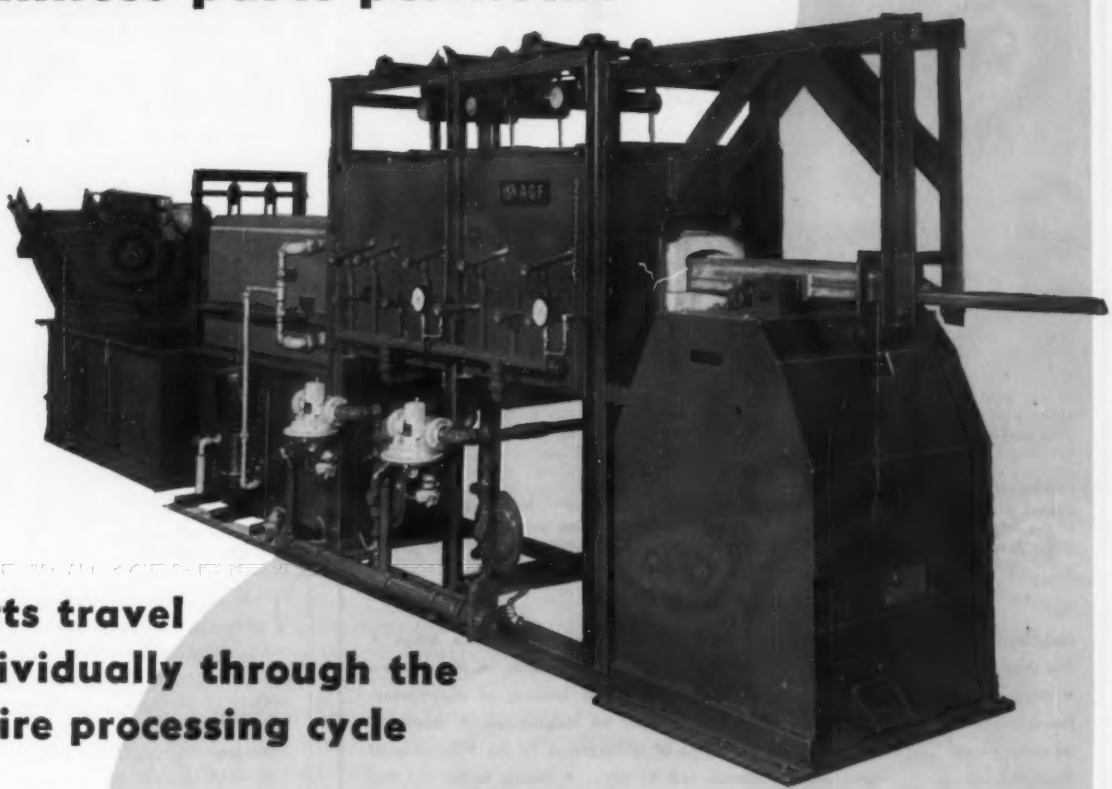

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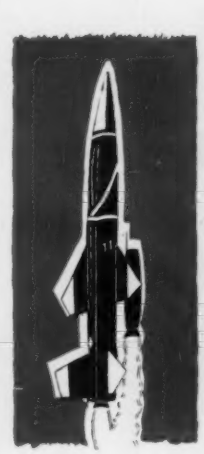

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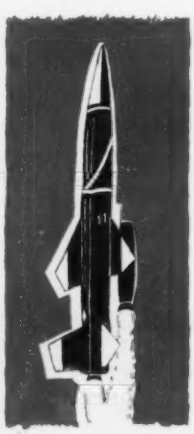

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Circle 544 on Page 48-A

Heat Treating . . .

ing in the part at the end of the cooling cycle is sufficient for tempering. This method saves heating costs, shortens the work cycle, decreases the furnace requirements, and makes it possible to integrate heat treatment into the mechanical production line.

In heat treatment of nonferrous metals, recent developments have included a sharp decrease in heating for hardening of aluminum castings. Casting is combined with hardening, and hardening with tempering. The annealing time is reduced through increase in temperature. Application of isothermal hardening in aluminum and other alloys should increase plastic properties of the casting.

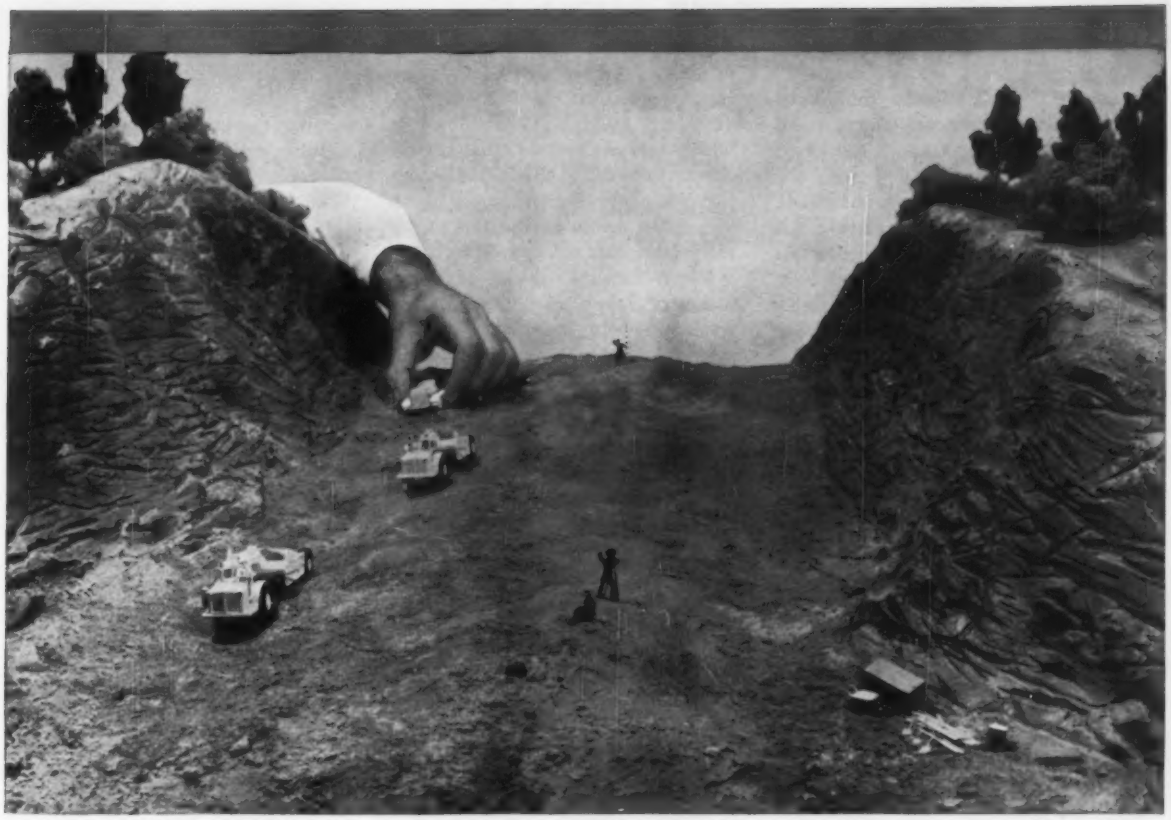
A. B. TESMEN

Energy in Deformed Metals

Digest of "The Energy Stored in Deformed Metals", by L. M. Clarebrough and M. E. Hargreaves, *Journal*, Australian Institute of Metals, Vol. 3, May 1958, p. 31-43.

THIS IS A REVIEW of the measurement of stored energy in plastically deformed copper and nickel. The work was performed at the University of Melbourne in Australia recently. First, a very short and elementary discussion of two types of lattice defects – the dislocation and the vacancy – is given. In a simple way, it is shown how dislocations are necessary to explain slip in crystals. During plastic deformation, the number of dislocations and vacancies is increased. Whereas most of the external energy introduced into a sample during plastic deformation is dissipated as heat, a small fraction becomes stored due to the lattice distortion around these defects. If a deformed crystal is annealed at increasing temperature, the various kinds of defects are eliminated at different temperatures, and the energy stored in the lattice distortion is liberated. By measuring released energy, it is possible to obtain information on type and concentration of defects.

Since the amount of heat liberated is very small, reliable measurements



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Circle 513 on Page 48-A

Deformed Metals . . .

are only possible in a differential calorimeter where the power input to heat a deformed sample to a given temperature is compared with the power input to heat an undeformed, but otherwise identical, sample. A description of the experimental arrangement is given.

Finally, the experimental measurements of stored energy in copper and nickel samples deformed in torsion are given. Most of the energy in deformed pure copper is released in a single peak between 200° C. (400° F.) and 300° C. (575° F) at which recrystallization takes place. At the same time, the hardness and the electrical resistivity drop. Both properties have a lower value in the recrystallization structure which has a lower dislocation density. As the extent of deformation increases, the total energy stored increases and the recrystallization temperature decreases. By using theoretical values for the dislocation energy, it is possible to obtain measurements of dislocation density in deformed metals.

Introduction of impurity atoms tends to increase the recrystallization temperature, and also changes the recovery spectrum. This is explained by the interaction between dislocations and impurity atoms which impede the movement of dislocations. Also, the arrangement of dislocations has an important influence on the released energy. This is shown by deforming samples of various grain sizes and by deforming in fatigue tests. Whereas in copper the mobility of vacancies is so high that they anneal out easily at room temperature (and hence do not show an effect in these experiments), it is possible to observe annealing in nickel. There, the recovery spectrum shows the recrystallization peak around 600° C. (1100° F.) but there is also a second peak around 200° C. (400° F.) which is attributed to the disappearance of vacancies. As expected for this process, there is no change in hardness, but there is a slight decrease in electrical resistivity. By measuring at the same time the increase in density of the crystal, one can obtain information on the number of vacancies and hence also on the energy per vacancy. Finally, the change in density per dislocations can be measured. This value compared favorably with some later theoretical estimates made. G. SCHOECK

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Circle 545 on Page 48-A

Cold Working Surfaces

Digest of "New Method of Working Machine Part Contact Surfaces", *Metallovedenia i Obrabotka Metallov*, No. 11, 1958.

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(Continued on page 190)

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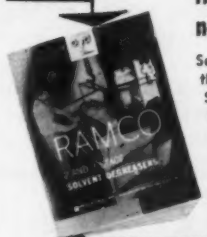

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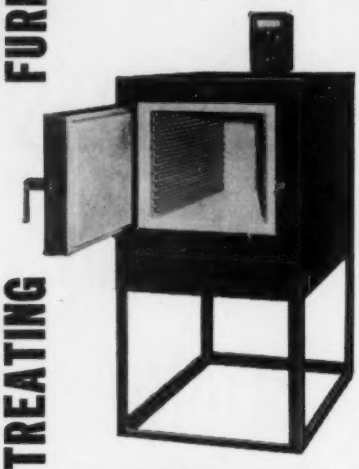

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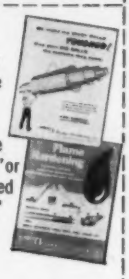

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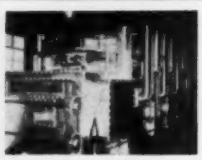

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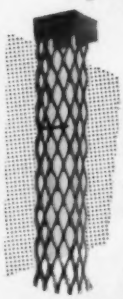

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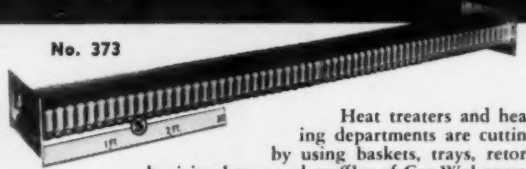
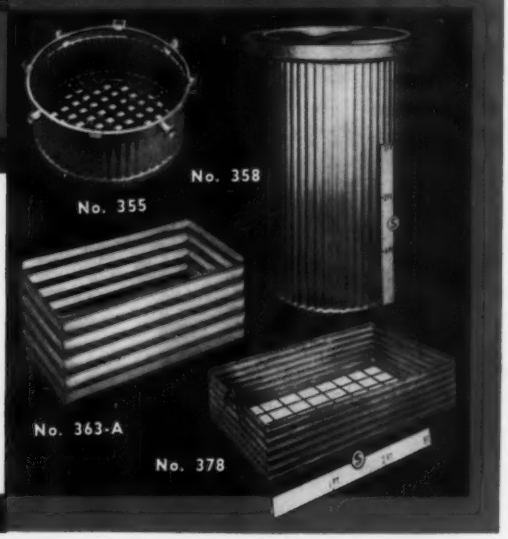
HEAT TREATING EQUIPMENT with COR-WAL® CONSTRUCTION CUTS COSTS!



Heat treaters and heat treating departments are cutting costs by using baskets, trays, retorts, carburizing boxes and muffles of Cor-Wal construction —the corrugated alloy absorbs the thermal stresses. This important development results in savings for users. Send for literature.

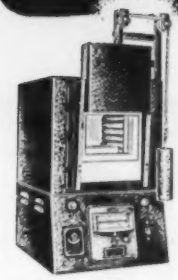


STANWOOD CORPORATION
4817 W. CORTLAND ST.. CHICAGO 39, ILLINOIS

Representatives in Principal Cities

LIST NO. 12 ON INFO-COUPON PAGE 189

HUPPERT ELECTRIC FURNACES AND OVENS
for Laboratory and Plant



BENCH MODELS

- **Range: 300°F. to 2000°F.**
- **High temperature, heavy-duty Kanthal elements**
- **Multi-insulation**
- **Counter-weighted, tight-sealing door**
- **Operational pilot light**
- **Shipped ready to operate**

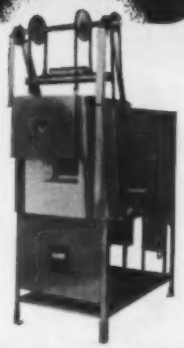
Model No.	Inside Dimensions Wide	High	Deep	KW	Prices 220 Volt Single Phase With Huppert Input Controller	With Electronic Prop. Controller
869	8"	6"	9"	4	$296.00	$480.00
11*	8"	6"	12"	4	306.00	518.00
12*	8"	8"	12"	6	382.00	590.00
12A*	8"	8"	18"	9	490.00	698.00

*For 2300°F. add $95.00 to No. 11 and No. 12, and $105.00 to No. 12A. No. 12A can be furnished for 3 phase at no additional cost. For floor model add $52.00 to above prices. No. 869 standardly supplied for 2200°F.

FLOOR MODELS
28 Standard Sizes

- **Continuous operation to 1850°F.—intermittent to 1950°F.—for 2300°F. on special order.**
- **Complete with automatic electronic controller.**
- **Tight-sealing, wedge-type door.**
- **Multi-insulation for maximum efficiency.**

Shipped Ready to Operate
Model No. 16 Illustrated $1050.00



Also Special Models for Specific Requirements.
Special KR-Supers to 3100°F.

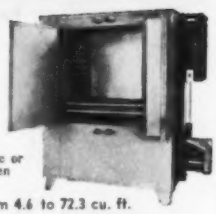
K. H. HUPPERT CO.
Manufacturers of Electric Furnaces and Ovens For A Quarter Century
6844 Cottage Grove Ave., Chicago 37, Illinois

Request new catalog on furnaces, ovens, data, prices.

LIST NO. 194 ON INFO-COUPON PAGE 189

UNIFORM HEAT
throughout the work space

30 STANDARD CABINET MODELS



Model HB Electric or Gas Cabinet Oven

- Work space from 4.6 to 72.3 cu. ft.
- Temp. ranges from 100 to 1250° F.
- Electronic combustion devices for gas models
- Indicating control instrument
- Factory tested

Other ovens from $121.50 up; laboratory, bench, walk-in and custom built models.

Write for details

Specialists in Heat Process Equipment

GRIEVE-HENDRY CO. Inc.
1339 N. Elston Ave. Chicago 22, Ill.

LIST NO. 27 ON INFO-COUPON PAGE 189

SUB-ZERO
low temperature equipment

for

- shrink fits
- seasoning gauges
- precision tools
- laboratory testing

1.5 and 6.5 cu. ft. capacities. Sturdy, all-steel cabinet construction. Sublids for constant inside temperature. Adjustable temperature controls. Special accessories available.

For more information—Write to: **Revco INC.**
Deerfield, Michigan
Specialists in Trend-Setting Refrigeration

LIST NO. 200 ON INFO-COUPON PAGE 189

GOOD USED EQUIPMENT AT REAL SAVINGS TO YOU!

1—Like-new roller hearth furnace! Surface Combustion recirculating oven for tempering or aluminum treating. Inside work dimensions: 49 in. wide x 17½ ft. long x 26 in. high.

Gas-fired for 1200° F. Complete with automatic doors and fast discharge mechanism, two recirculating fans with 15 hp. (220x 440x3) motors, turbocompressor, safety equipment, and Brown Electronic strip chart recorders.

1—Same as above except 45 ft. long. Brick-lined.

Other Roller Hearths in stock:

G. E.—heat chamber 24 in. wide; heated length, 20 ft., height 10 in.; temperature range to 2100° F. 120 kw. 440/3.

Electric Furnace Co.—heat chamber 49 in. wide; length 34 ft., height 14 in.; temperature range to 2050° F. Radiant tube.

Electric Furnace Co.—heat chamber 66 in. wide; length 30 ft., height 43 in.; temperature range to 1500° F. Gas fired.

Electric Furnace Co.—heat chamber 66 in. wide; length 35 ft., height 25 in.; temperature range to 1800° F. Gas fired.

Price: 25% of replacement cost.

METAL TREATING EQUIPMENT EXCHANGE, INC.
9825 GREELEY ROAD
DETROIT 11, MICHIGAN

LIST NO. 142 ON INFO-COUPON PAGE 189

DOW
BATCH FURNACES
CONTROLLED ATMOSPHERE EQUIPMENT FOR EVERY APPLICATION

STANDARD HEARTH SIZES

20" Wide—30" Long
24" Wide—36" Long
30" Wide—48" Long

DOW FURNACE COMPANY

LIST NO. 230 ON INFO-COUPON PAGE 189

Regulate and control electric ovens and furnaces better, accurately, and efficiently with

SORGEL

Saturable Reactors

Any amount of A.C. power from 1 Kva to 3000 Kva, single phase or 3-phase, at any voltage, can be controlled, regulated, and varied in stepless increments, with SORGEL Saturable Reactors.

The control can be a small manually operated hand wheel that can be placed in any desired location, or it can be automatically controlled, regulated and varied by a thermostat or any other instrument or device.

SORGEL reactors are designed to meet your exact requirements. Let us know what your problems and requirements are, and we will submit our recommendations with complete information.

Write for Bulletin 658.

Saturable Reactor with tap changing transformer

●

Also a complete line of dry-type transformers.

All standard and intermediate ratings, ¼ Kva to 10,000 Kva, 120 to 15,000 volts.

●

Sales Engineers in principal cities

Consult the classified section of your telephone directory, under the heading "Transformers," or communicate with our factory.

Sorgel Electric Company

834 W. National Ave., Milwaukee 4, Wis.
Over 40 years of electrical manufacturing development

LIST NO. 195 ON INFO-COUPON PAGE 189

You can read temperatures instantly with the SHAWMETER

For flowing, moving or stationary objects

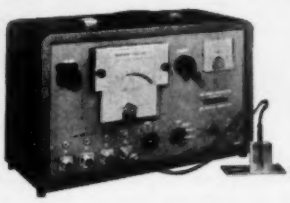
Send for new bulletin that gives detailed information on this unique instrument.

SHAW INSTRUMENT CORPORATION
P.O. Box M-46, Latrobe, Pennsylvania

LIST NO. 205 ON INFO-COUPON PAGE 189

THE NEW DERMITRON

NON-DESTRUCTIVE COATING THICKNESS TESTER



FAST... ACCURATE NON-DESTRUCTIVE DIRECT-READING

- Instantly measures the thickness of metallic and non-metallic coatings and films
- Based on eddy-current principles
- Enables measurements on small or otherwise inaccessible areas

This portable instrument for both laboratory and production use, gives fast, accurate and direct readings of virtually any coating on any base, including:

- Metal coatings (such as plating) on metal base (magnetic and non-magnetic)
- Non-metallic coatings (such as paint, anodizing, hard-coat, ceramic) on metal base
- Metal films (such as vacuum metalizing) on non-metallic base (plastics, ceramics)

Write for latest bulletins and questionnaire to help solve your thickness testing problems

UNIT PROCESS ASSEMBLIES, INC. UPA

LIST NO. 139 ON INFO-COUPON PAGE 189

FREE

the QUENZINE STORY

Low priced, more readily available carbon steels can often replace alloy steels when quenched in Beacon Quenching Oils with QUENZINE added. For information on this new additive and other Beacon Brand Heat Treating Compounds write to . . .

ALDRIDGE INDUSTRIAL OILS, Inc.
3401 W. 140th St., Cleveland 11, Ohio

LIST NO. 100 ON INFO-COUPON PAGE 189

make hardness tests ANYWHERE WITH THE **NEWAGE TESTER**

- CLAMPS, JAWS & BASE PLATE ARE ELIMINATED
- NO CONVERSIONS OR CALCULATIONS
- TEST ANY SIZE, SHAPE OR TYPE METAL
- NO SKILL REQUIRED
- SCALE READINGS IN ROCKWELL & BRINELL
- ACCURACY GUARANTEED

Many thousands used by industry and government. Write, wire or call for additional details and prices.

NEWAGE INDUSTRIES, INC.
222 York Road, Jenkintown 6, Pennsylvania
TUrner 4-8494 Dept. MP

LIST NO. 163 ON INFO-COUPON PAGE 189

HARDNESS TESTING
SHORE SCLEROSCOPE

Pioneer American Standard Since 1907

Available in Model C-2 (illustrated), or Model D dial indicating with equivalent Brinell & Rockwell C Hardness Numbers. May be used freehand or mounted on bench clamp.

OVER 40,000 IN USE

SHORE INSTRUMENT & MFG. CO., INC.
90-35M Van Wyck Exp., Jamaica 35, N.Y.

LIST NO. 133 ON INFO-COUPON PAGE 189

THERMOCOUPLES
PROTECTION TUBES
THERMOCOUPLE WIRES
LEAD WIRE INSULATORS

PROMPT SHIPMENT from STOCK

REQUEST CATALOG and QUOTATION

ARKLAY S. RICHARDS CO., INC.
manufacturers since 1938
74 Winchester Street
NEWTON HIGHLANDS 61, MASS.

LIST NO. 31 ON INFO-COUPON PAGE 189

TENSILKUT®

Pat. Pend., U.S., Canada

● Now with TENSILKUT, whatever your testing methods or materials, you can have perfect precision machined physical test specimens in less than two minutes.

● TENSILKUT precision machines all foil, film, sheet and plate metals . . . from .0005" foil to .500" plate. Hard .001 stainless steel foil to soft ½" aluminum, soft plastic film 1 mil in thickness or the abrasive glass laminates in .500" plate, are machined with specimen configurations accurate to ± .0005". Machined edges are completely free of cold working or heat distortion and require no hand finishing.

● TENSILKUT table and floor models are available with motors from ⅓ to 2½ h.p. Write for free brochure.

SIEBURG INDUSTRIES INCORPORATED
Danbury Industrial Park, Danbury, Connecticut

LIST NO. 131 ON INFO-COUPON PAGE 189

Solve
Inspection
Sorting
Demagnetizing
Problems
with
MAGNETIC ANALYSIS...

MULTI-METHOD EQUIPMENT

Electronic equipment for non-destructive production inspection of steel bars, wire rod, and tubing. Detects mechanical faults and variations in composition and physical properties. Average inspection speed — 120 ft. per minute.

MULTI-FREQUENCY EQUIPMENT

An eddy current tester with six inspection methods operating simultaneously — for high-speed, non-destructive testing of non-ferrous and non-magnetic tubing, bars and wire from ⅛" to 3" diameter. Detects both surface and sub-surface flaws, and variations in chemical, physical and metallurgical properties at speeds of 200 to 600 ft./min.

WIRE ROPE EQUIPMENT

Electronic equipment for inspecting ferro-magnetic wire ropes from 1/32" to 3" diameter. Detects broken, cross-over or missing wires, plus defective welds and deformations at production speeds up to several hundred feet per minute.

COMPARATORS AND METAL TESTERS

Electronic instruments for production sorting of both ferrous and non-ferrous materials and parts for variation in composition, structure and thickness of sheet and plating.

DEMAGNETIZERS

Electrical equipment for rapid and efficient demagnetizing of steel bars and tubing. When used with Magnetic Analysis Multi-Method Equipment, inspection and demagnetizing can be done in a single operation.

MAGNETISM DETECTORS

Inexpensive pocket meters for indicating residual magnetism in ferrous materials and parts.

TRADE MARK

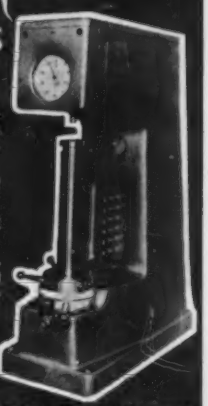
"THE TEST TELLS"

For Details Write:

MAGNETIC ANALYSIS CORP.
42-44 Twelfth St., Long Island City 1, N. Y.

LIST NO. 51 ON INFO-COUPON PAGE 189

Frank NEW DUPLEX HARDNESS TESTER



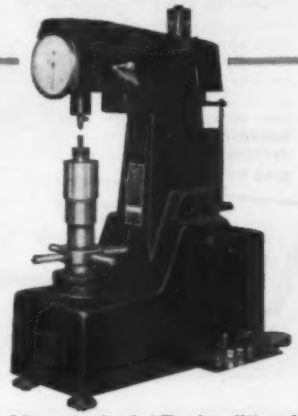
for all NORMAL AND SUPERFICIAL Tests in ONE low-priced machine. 6 Major loads of 150, 100, 60, 45, 30 and 15 kg available by push-button control, plus selective 10 and 3 kg minor loads.

Request Circular #506

OPTO-METRIC TOOLS, INC.
137 W. VARICK STREET, NEW YORK 13.

LIST NO. 162 ON INFO-COUPON PAGE 189

Wilson "Rockwell" TWINTESTER



- Measures both "Rockwell" and "Rockwell" Superficial hardness on B, C, N, T and other scales
- Easy to operate—change from "Rockwell" to "Rockwell" superficial testing in seconds
- Large direct-reading dial with one zero set position for all scales
- Complete equipment includes cowl, ball penetrator for B and T scale, "Rockwell" test blocks, anvils, dust cover, and protective sleeve set
- Complete line of accessories available

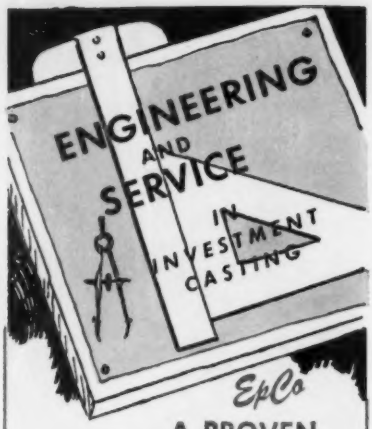
***Write** to Dept. DU. Ask for Bulletin TT-59*

WILSON "ROCKWELL" HARDNESS TESTERS

Wilson Mechanical Instrument Division
American Chain & Cable Company, Inc.
230-F Park Avenue, New York 17, N.Y.

ACCO

LIST NO. 209 ON INFO-COUPON PAGE 189

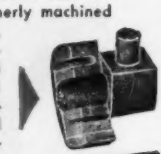


EpCo

A PROVEN DEPENDABLE SOURCE
FOR BETTER GRADE INVESTMENT CASTINGS IN FERROUS AND NON-FERROUS METALS

INVAR CASTING Special Feature — Nickel content held to 35% minimum — 36% maximum

STAINLESS STEEL PART for milk bottling unit formerly machined from solid stock. Only finish operations required are reaming small dia. of counterbored hole and drilling and tapping for set screw.



ENGINEERED PRECISION CASTING CO.

MORGANVILLE, N. J.

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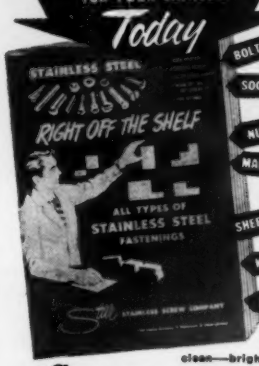
WRITE, WIRE or PHONE FOR YOUR CATALOG Today



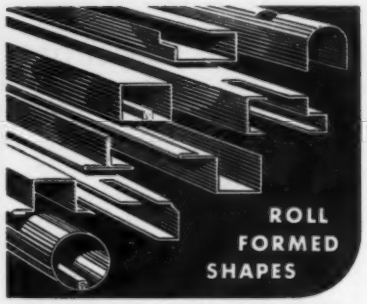
BOLTS & CAP SCREWS
SOCKET, SET & CAP
NUTS, WASHERS
MACHINE SCREWS
SHEET METAL SCREWS
WOOD SCREWS
PIPE FITTINGS

Star Stainless screws have clean—bright—shiny—heads

STAR STAINLESS SCREW CO.
647 Union Blvd., Paterson 2, N. J.
Telephone: CLifford 6-2300
Direct N.Y. 'phone Wisconsin 7-6310
Direct Phila. 'phone WAlnut 5-3660

CORROSION RESISTANT

LIST NO. 99 ON INFO-COUPON PAGE 189



ROLL FORMED SHAPES

Reduce your assembly problems and costs. Our shapes continuously formed, with high degree of accuracy, from ferrous or non-ferrous metals. Write for Catalog No. 1053.

ROLL FORMED PRODUCTS CO.

MAIN OFFICE AND PLANT
3761 OAKWOOD AVE. • YOUNGSTOWN, OHIO

LIST NO. 101 ON INFO-COUPON PAGE 189

MOVE IT FASTER
...over any surface!

The New WIRETEX Model B-1 TRAY for pusher and horizontal type furnaces is designed to cut "moving" costs. Tapered runners permit riding over the roughest surface and obstructions freely. Compact! Rugged arc (not pressure welded) welded construction assures a long life under the highest temperatures.

Standard units: 34" long, 22" wide, 6" high. *Other sizes,* all metals and alloys available.

Call WIRETEX for all your heat treating fixtures, and save.

Wiretex mfg. co.,
5 Mason Street, Bridgeport 5, Conn.
Specialists in Processing Carriers Since 1932.

LIST NO. 114 ON INFO-COUPON PAGE 189

NEW! THE WORLD'S FIRST HEAT RESISTANT 24K Acid Bright Gold

OROTHERM HT

HEAT RESISTANCE
5 HOURS 400°c Minimum

HARDNESS
150+ KNOOP

BRIGHTNESS
MIRROR

CONTROL
ONE ADDITION AGENT

TEMPERATURE RANGE
65°F to 115°F

OPERATION
BARREL or TANK

For complete information
Write, Wire, Phone or TWX

PRODUCTS OF RESEARCH

Technic inc ST 1-6100
P.O. BOX 965 PROVIDENCE, R. I.
7001 NO. CLARK ST. CHICAGO 26 ILL.

LIST NO. 124 ON INFO-COUPON PAGE 189

other extruders
said it couldn't be done . . .

GENERAL DID IT!

The manufacturer of heaters wanted a hearth bottom — a fluted, gold-anodized aluminum extrusion. Specifications called for a 7" x .050" shape. Extruders with presses that take 8" diameter billets said it couldn't be done because of the thinness, too great a reduction ratio.

G.E.I. engineers came up with the extrusion, on a 5" press! The shape is extruded half round, then straightened, notched and bent, holes punched, and finally gold-anodized.

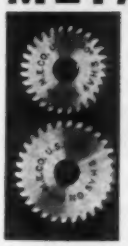
If you have a problem involving aluminum fabrication, finishing or extrusion, why not take it to General, pioneers in developing new uses for extruded aluminum.

GENERAL EXTRUSIONS, INC.
4040 Lake Park Rd., Youngstown, Ohio
Sales Offices at St. Louis, Detroit, Pittsburgh, Cleveland, and Chattanooga

Consult your classified phone book under Aluminum Products

LIST NO. 141 ON INFO-COUPON PAGE 189

MARTINDALE
METAL SAWS



for fast, precision sawing, slotting, mica undercutting

•

HIGH SPEED STEEL OR TUNGSTEN CARBIDE

Milled, hardened and ground by skilled, experienced craftsmen to exacting specifications. Available in ⅛" to 4" O.D., complete range of thicknesses and tooth designs, "U" slot or "V" cutters. Get finest saw blade performance—lowest operating cost.

***Send for NEW CATALOG* and prices on these and other maintenance, safety and production products.**

MARTINDALE ELECTRIC CO.
1372 Hird Avenue Cleveland 7, Ohio

LIST NO. 216 ON INFO-COUPON PAGE 189

the GENUINE
BRINELL
HARDNESS TESTING MACHINES made by the Alpha Co. of Sweden and available from our stock at New Rochelle

Never approached in ACCURACY AND CONSTANCY of calibration . . . at the standard 3000kg test load . . . maximum error plus or minus 2½ kg

Write for Bulletin No. A-18

GRIES INDUSTRIES, INC.
Testing Machines Division
NEW ROCHELLE 3, N. Y.

LIST NO. 135 ON INFO-COUPON PAGE 189

GET A BID FROM

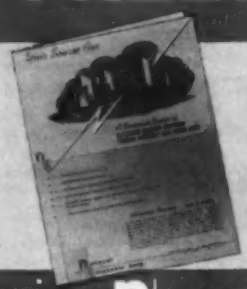
HOOVER

SPECIALISTS IN THE FIELD OF
Die Castings
SINCE 1922
Aluminum and Zinc

THE HOOVER COMPANY
Die Castings Division
North Canton, Ohio
In Canada—Hamilton, Ontario

LIST NO. 74 ON INFO-COUPON PAGE 189

FREE! ULTRASONIC CLEANING BULLETIN



Describes National Ultrasonic Corporation's:

- Applications Laboratory service. Your sample parts are cleaned ultrasonically and equipment and cost recommendations are made at no charge.
- STANDARDLINE medium power cleaners for all applications requiring average energy levels.
- HEAVYDUTYLINE high power cleaners for industrial applications requiring high energy density.
- NUclean® solvents and detergents especially formulated for ultrasonic cleaning.

NATIONAL ULTRASONIC CORP.
111 Montgomery Ave., Irvington 11, N. J.
ESsex 1-0550 • TWX NK 1030

LIST NO. 240 ON INFO-COUPON PAGE 189

All The Best

HEAT RESISTING ALLOYS

Ready When You Need Them

Please Send for Stock List and Literature

ROLLED ALLOYS, INC.
Heat and Corrosion Resistant Alloy Specialists

5309 Concord Avenue • Detroit 11, Michigan
Phone WAlnut 1-4462

330 William Street • South River, New Jersey
Phone CLifford 4-4616

LIST NO. 234 ON INFO-COUPON PAGE 189

Need Help Designing That Aluminum Extrusion?

TEAM UP with JARL

THERE'S A WORLD OF DIFFERENCE

The *difference* starts the moment you meet the Jarl salesman. He's an engineer . . . well qualified to make on-the-spot recommendations in designs. Team up with Jarl and you'll get the right shapes made to most exacting design specifications. You'll be sure of close die control . . . quality safeguards every step . . . on-time deliveries. Send for our stock die catalog or send rough sketches for assistance with your design.

ANODIZING

JARL EXTRUSIONS, INC.
Dept. MP, Linden Ave. • East Rochester, N. Y.

LIST NO. 165 ON INFO-COUPON PAGE 189

Whitelight MAGNESIUM

your comprehensive independent mill source of magnesium alloy . .

ALLOYS
AZ10
AZ31
AZ51
AZ61
AZ81
ZK60
ZK30
M-1
ZK-20
Anodes

RODS ¼" dia. to 6½" dia.
BARS, STRIPS .022" min. to 7¾" max
SOLID SHAPES .022" min. to 6½" circle
TUBING ¼" O.D. to 8" O.D.
HOLLOW SHAPES ½" to 6½" circle
PLATE & SHEET .092" to 3" thick

WHITELIGHT MAGNESIUM

WHITE METAL ROLLING & STAMPING CORP.
82 Moultrie Street, Brooklyn 22, N.Y.
Factories: Brooklyn, N.Y. • Warsaw, Ind.
Los Angeles Warehouse: 6601 Telegraph Rd.

LIST NO. 243 ON INFO-COUPON PAGE 189

FIND CRACKS QUICK!

Use Spotcheck
"SPRAY-ON"
Dye Penetrant Inspection

QUICK TEST ENDS VISUAL GUESSWORK!

SPOTCHECK finds cracks, porosity, and leaks you can't see (any defect open to the surface). SPOTCHECK—marks them with a brilliant red warning. Users report speedy, money-saving results. SPOTCHECK is used to inspect metals, carbides, ceramics, plastics, etc. Multi-use SPOTCHECK can simplify your maintenance and in-progress inspections. SPOTCHECK'S complete SK-3 kit is portable; no other equipment needed!

NEW! NONFLAMMABLE
PUSH-BUTTON EASE
FLEXIBILITY . . . Use on tools, parts, machinery, etc.
LOWEST COST Dye Penetrant materials — pressure canned or bulk. Why use higher priced substitutes?

COMPLETE SK-3 KIT ONLY

U. S. A. only
Plus $1 for packing and shipping

CALL YOUR DISTRIBUTOR or Mail Check or P. O. with Coupon Today!

MAGNAFLUX CORPORATION
7328 W. Ainslie Ave., Chicago 31, Illinois

☐ Please send____SK-3 kits @ $36.00 each plus $1.00 each packing and shipping.
☐ Send FREE bulletin only. Includes low SPOTCHECK material prices.

Name_____Title_____
Company_____
Address_____
City_____Zone____State_____

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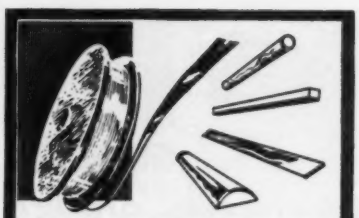

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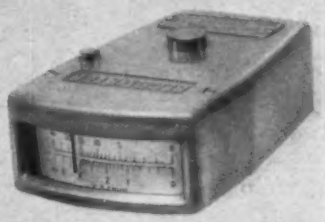

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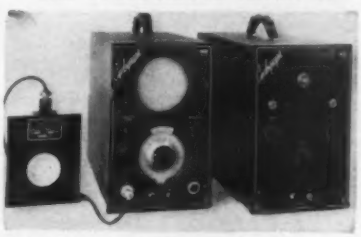

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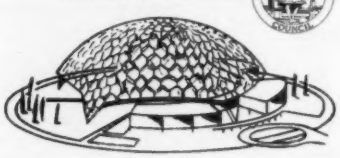

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Circle 546 on Page 48-A

Cold Working . . .

are induced. This method of surface improvement is used in the manufacture of frame-type powerful hydraulic presses with thick walls at the Novo-Kramatorsk Machinebuilding Plant in Donbass. The Central Research Institute of Machinebuilding in Moscow has been studying the increase in the resistance of slip of the contacting surfaces resulting from rifling, and the increase in the fatigue strength from cold work induced by rifling.

Steel 3 (nominal composition: 0.14 to 0.22 C, 0.35 to 0.65 Mn, 0.12 to 0.30 Si, 0.055 S max., 0.050 P max.) has the following mechanical properties: tensile strength 59,500 psi., yield strength 34,800 psi., elongation 35%, reduction in area 67.8%, Brinell hardness 135 to 143.

Slip test specimens consisted of three plates, bolted together, with spring devices measuring contact pressure. Grooves and crests produce a fit, sharply increasing slip resistance. Fatigue specimens consisted of plates about 2 in. thick. Grooves were hammered at the rate of 750 strokes per min. with the workpiece moving at 1 ft. per min. and a hammer force of about 1 lb.

Results of fatigue tests of smooth and grooved specimens at 10 million cycles are shown below. (Specimens which did not reveal defects to the naked eye were examined magnetically.) Unit contact pressure was about 700 psi.

Type Surface	Fatigue Strength
Smooth	20,500 psi.
Smooth	9,300
Grooved	26,800

Results of slip tests show that the increase in bearing pressure from 280 to 2800 psi. has a much lesser effect upon slip resistance of grooved rather than smooth surfaces.

Effect of Rifling Methods

Studies of the effect of rifling variables showed that, by varying the number of strokes per minute and the rate of travel of the workpiece during hammering and the distances between the grooves, variations were produced in the crest heights of the rifling, from a Brinell hardness under 180 to 200, in resistance to slip from

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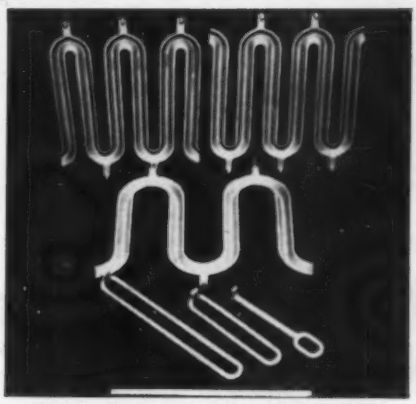
Duraloy Centrifugally Cast Tubes 7'9" long, 7" O.D., ⅜" wall. 28 Cr 10 Ni; some of HOM alloy.



Duraloy Resistance Grids—Shell Molded. 18 Cr 38 Ni; some of special HOM alloy.

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One reason—indeed the major reason—why The Electric Furnace Company, Salem, Ohio, has leaned so heavily on Duraloy for its castings is that over the years Duraloy Castings have established a fine record for durability and uniformity. And with the recent development of Duraloy HOM, the furnace company can work towards higher temperature operations. HOM can be used quite broadly at temperatures up to 2200°F and in a limited way to 2300°F. It can be cast statically, centrifugally and shell molded.

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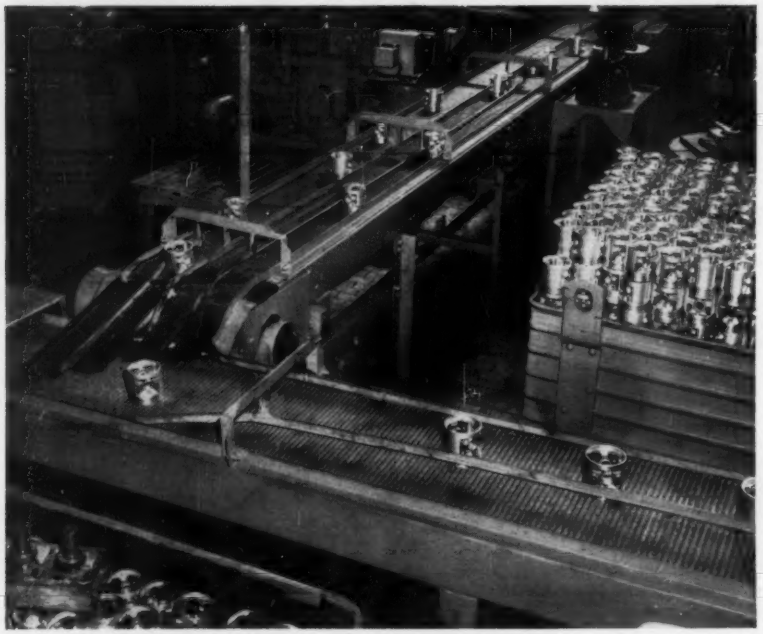
Continuous Heat Treating Depends on Continuous Product Flow and...



Aluminum piston heads flow on Ashworth Balanced Weave design B 60-38-14. It affords the required smooth surface characteristics to facilitate transfer and minimize product marking.

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Circle 547 on Page 48-A

Cold Working . . .

16,000 to 34,000 psi., and in fatigue strength from 9300 to 26,800 psi.

The effect of eccentric loading rifled plates is to decrease somewhat the slip resistance, the latter still remaining 9 to 12 times that of unrifled surfaces. The effect on the fatigue strength was insignificant. It was also found that the slip resistance was not affected by differences in groove spacings of the contacting plates.

To summarize, this method of surface working of contact surfaces of machine parts consists of cold working and rifling these surfaces by special hammers. Fatigue strength is increased twofold and more, and resistance to slip relative to each other – 80 to 300 times. This method is used successfully for thick-walled frames of powerful hydraulic presses to increase rigidity and to double bearing strength. It is recommended for components and installations subjected to cyclic stresses of long duration and requiring retention of rigidity, such as frames of metalforming machines, press tables, laminated assemblies.

A. B. TESMEN

A New Metal Forming Process

Digest of "Dyzacking—a Method of Obtaining a Quick Get-Away From Design to First Part Off", by John A. Grainger, *Sheet Metal Industries*, April 1959, p. 271-279.

THE PRESENT-DAY tendency, particularly in press forming, appears to be toward the development of tools and machines designed for faster production. Although these efforts are fascinating, the production engineer is often faced with the problem of providing comparatively small quantities of parts to close tolerances and at competitive costs. Moreover, he is often required to provide a few prototype or preproduction parts. These preproduction quantities should be produced by some form of economical tooling.

In general, the efforts to reduce tooling costs have been centered around the elimination of one of the most costly parts of the tool, either

One of a series

On the riddle of rolling friction

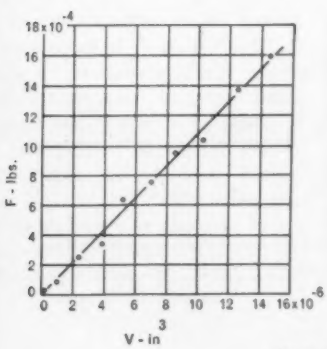
It doesn't take much to roll a hard ball across a hard, smooth, level surface – actually only about 0.00001 times the normal force acting vertically on the ball. But by careful measurement of this tiny rolling force, scientists at the General Motors Research Laboratories are helping to unravel the riddle of rolling friction.

An important relationship recently uncovered in this fundamental study: the rolling force is proportional to the volume of material that is stressed above a certain level. As a result, a GM Research group have not only confirmed the hypothesis of *how* a rolling ball loses energy (Answer: elastic hysteresis) but also have learned *where* this lost energy is dissipated (Answer: in the interior of the material, not on the surface). Mathematical analyses have indicated the exact shape of the elastically stressed volume in which all the significant frictional loss takes place.

The purpose of friction research at the GM Research Laboratories is to learn more about the elastic and inelastic behavior of materials. This knowledge – of academic interest now – will eventually give GM engineers greater control of energy lost through friction. This is but one more example of how General Motors lives up to its promise of "More and better things for more people."

General Motors Research Laboratories

Warren, Michigan



Relationship of rolling force to elastically stressed volume.

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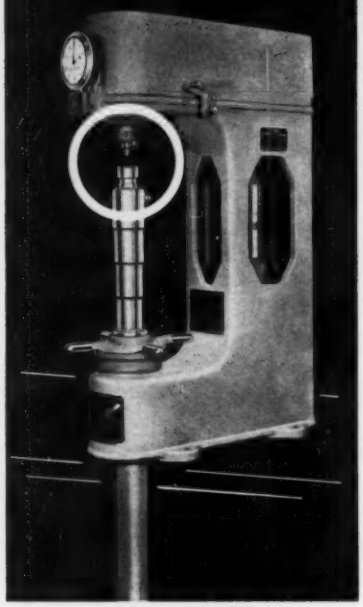

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Missile-Age Accuracy

Circle 548 on Page 48-A

Metal Forming . . .

the die or the punch. The machine toolmakers have, therefore, directed their effort toward producing a machine incorporating a mechanism which would be a universal substitute for one of the costly tooling components. Most of these machines have successfully performed the desired function. However, their high costs have resulted in prohibitive amortization rates.

The firm of Mark Tyzach and Sons Ltd. of Sheffield, England, recognized the potential of the drop stamping process, previously used by silversmiths, as a possible contender in the field of cheap tooling. Its effort in the development of this technique led to a patented process called "Dyzacking".

This process is essentially an impact forming method developed from the traditional techniques used by the silver and electroplate trades for the production of sheet metal hollow ware. The sequence of operations is as follows:

A cylindrical slab of lead is cast on the hammer block in an improvised mold fashioned from a strip of thin sheet metal and sealed around the bottom edge with a fillet of plumbago. After the lead is solidified, the strip of metal is removed from the lead slab. The slab is then struck a hard blow by the tup. The face of the tup has a series of dovetailed grooves such that when the lead slab is forced into these grooves by two or three additional hard blows, the lead "force" is securely fastened to the face of the tup.

Following this, the first of a series of dies is centered and fastened on the bed of the percussion hammer. The lead "punch" is then driven into the die mouth for a short distance to shape it to the contour of the die. To provide for metal clearance, a soft metal blank, usually brass, is then placed in the liner. When the "punch" is subsequently driven into the die, the lead is formed to the proper size and contour. A run of metal blanks of the correct material is then passed through the tools.

The process of driving the lead "punch" into the die, sizing on a soft metal liner and processing the run of blanks is repeated on each of the dies of the series. This sequence progressively forms the punch and

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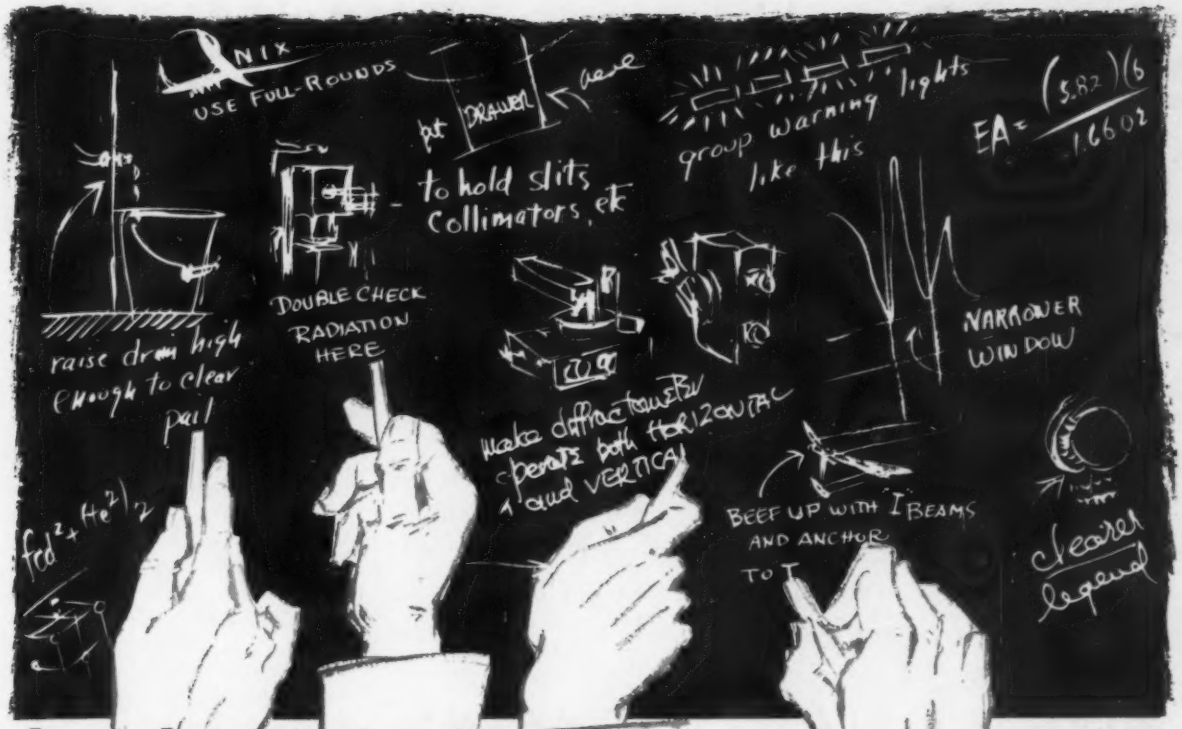

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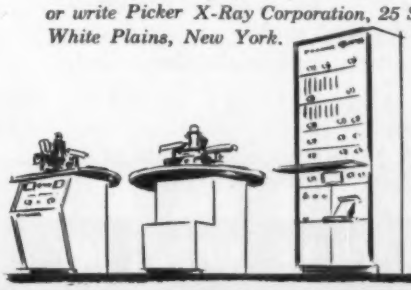

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Circle 519 on Page 48-A

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Circle 550 on Page 48-A

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Circle 551 on Page 48-A

Metal Forming . . .

the blanks until the finished die is reached. For the finishing operation, it may be necessary to consider the use of alternate materials for the punch. When the product contours are generously rounded, a lead "force" may be satisfactory. With sharper radii, however, the final sizing punch must be made from such materials as cast tin, cast zinc or machined mild steel. If the radii are so small that a mild steel punch is required, a part of the value of the process is lost as machining is required.

Many parts have been produced by this process since it was perfected. These products range from simple shallow cylindrical forms to relatively deep drawn articles of various forms. Parts with reverse depressions in the base have also been made. Conical parts which are sometimes difficult to form on normal double action drawing presses have been formed.

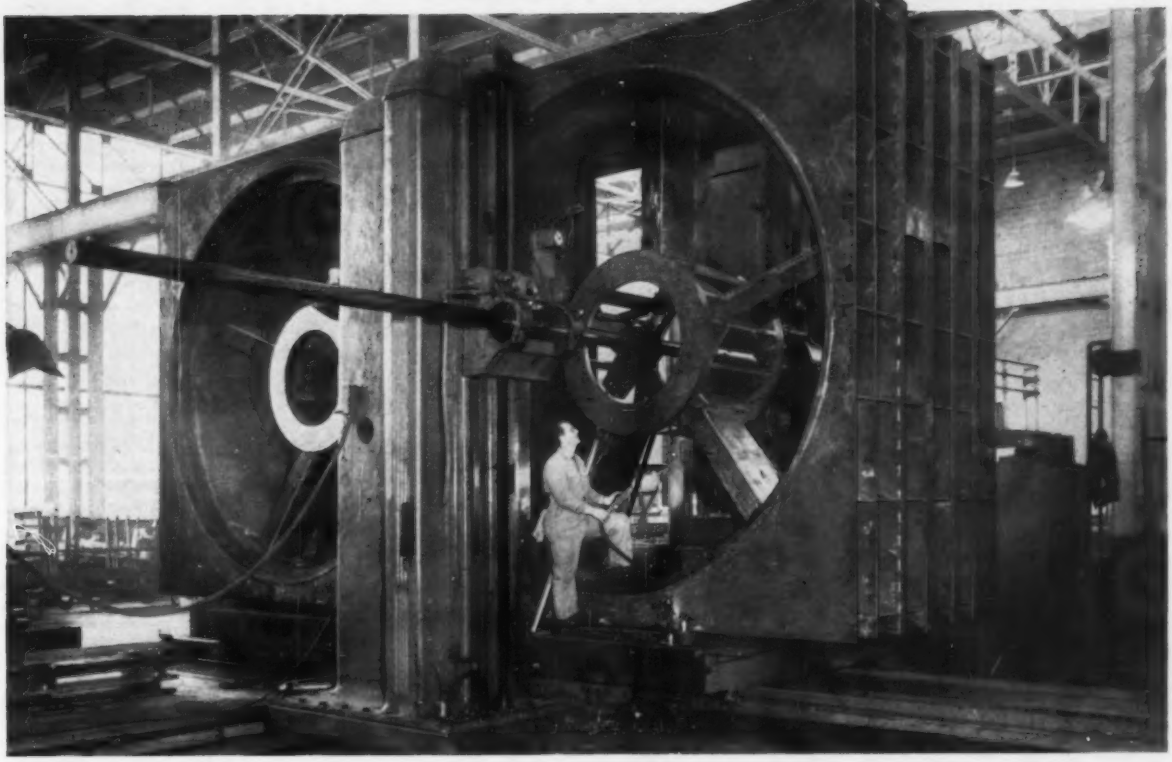
Accuracy has been of a high order, comparing favorably with normal press forming. Variation in metal thickness has been small, generally about 0.002 to 0.003 in. on 0.048-in. thick material. The surface finish of the formed parts has been excellent.

The process offers a number of advantages when limited production runs or prototype quantities of pressed parts are required. The process offers a very low tooling cost, but a larger forming or operating cost per piece than conventional pressworking methods. Where a product requires a multiplicity of press tools and the individual batches are very large, orthodox press methods make far better use of the labor content of the operating cycle. As the size of the individual batches decrease, however, the advantages of normal press methods are less evident and ultimately a point is reached where "Dyzacking" becomes more economical.

In addition, the process offers a minimum time delay between final design and the first part off the tools. It also furnishes great flexibility which permits fast modification of prototypes and it is a valuable asset to any experimental development program. R. F. HARTMANN

(More digests on p. 198)

STEEL-WELD FABRICATION . . .



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The two weldments illustrated above are wind tunnel sections designed with motor mounts to house giant propellers driven by electric motors. These husky pieces are typical of thousands of Steel-Weld Fabricated parts and assemblies produced and machined by Mahon for defense contractors and manufacturers of processing machinery, machine tools, and other types of heavy mechanical equipment.

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Circle 520 on Page 48-A

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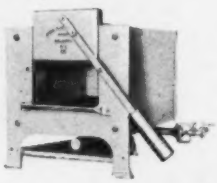
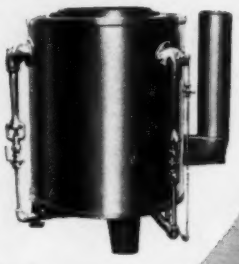
for Clean, Fast, Quiet Heat-Up at Lowest Cost!

BENCH TYPE OVEN FURNACES
For heat treating and pre-heating.
Temperatures to 2000° F.





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ATMOSPHERIC POT FURNACES
For cyanide, salt bath and lead hardening. Temperatures to 1650° F.

Est. 1911
CHARLES A. HONES, INC.
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"BUZZER" Burners & Furnaces for Heat Treating, Melting, Soldering

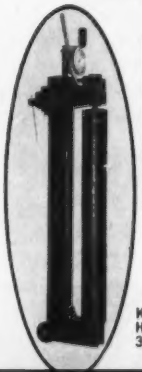
Circle 552 on Page 48-A

MAKE ALL BRINELL HARDNESS TESTS WITH The KING PORTABLE TESTER

King Test Head with Chain Adapter

King Test Head in 13½" base with King Brinell Scope

ONE TEST HEAD FITS MANY INEXPENSIVE ADAPTERS



King Test Head in 30" base

King Bore Brinell with small test head for pipes, cylinders, etc.

The KING PORTABLE HARDNESS TESTER

- To test any size, shape or thickness of metal.
- Makes guaranteed accurate on-the-spot tests — anywhere!
- Gap 10" — 13½" — 30". Throat 4" — 6¾" or larger with chain adapter.
- Loads from 62½ Kg. to full 3000 Kg. 5mm or 10mm steel or carbide ball.
- Will make tests in places no other tester can reach—including cylinder bores.

Write for literature and prices to Dept. MP-160

KING TESTER CORPORATION 440 N. 13th St., Philo. 23, Pa.
Known the world over for accuracy and dependability

Circle 553 on Page 48-A

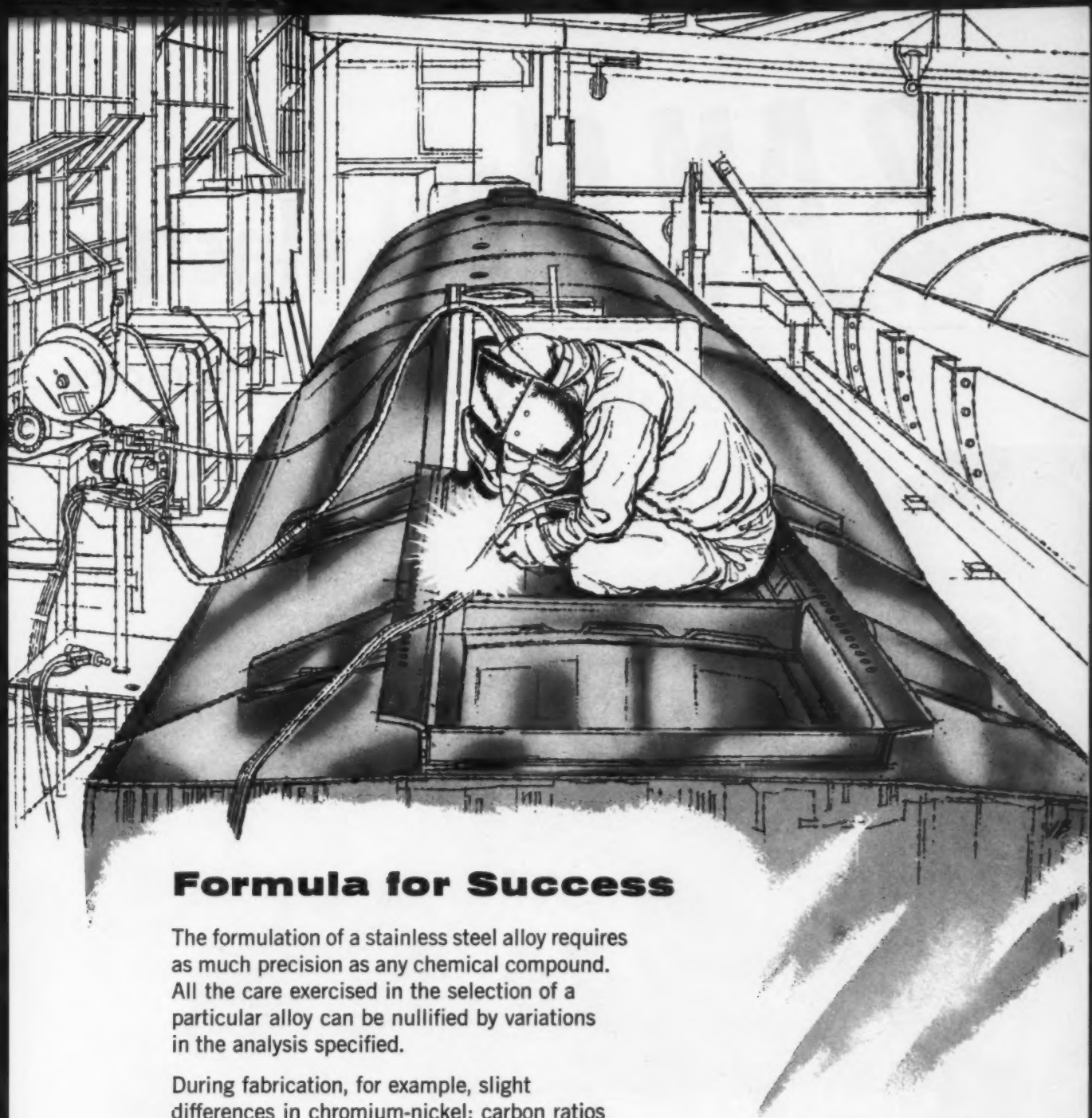
Nuclear Meeting

Digest of notes compiled at the annual meeting of the American Nuclear Society in Gatlinburg, Tenn., June 15 to 17, 1959.

INFORMATION is sadly lacking on the effects of power transients, and the subsequent temperature effects on irradiated or partially irradiated fuel element components. The normal temperature excursions which result from power transients expose reactor fuel alloys to temperatures that exceed or approach the transformation temperature. Obviously, it is not safe to use the reactor for experimental purposes. Therefore, plans have been discussed, and a working arrangement arrived at, that will simulate the condition that exists periodically, but nonuniformly, in a reactor. It is now set up as a pilot-type operation in an irradiation laboratory. A radio-frequency induction coil, set up in the Bettis Atomic Power Radiation Laboratory, has been successfully operated by remote control. The metallurgical approaches to testing irradiated fuel alloys completely clad have been many fold. One approach follows:

From a metallurgical standpoint, it is very desirous to know how material stability is affected when a fully irradiated (that is, a high uranium depletion) fuel alloy is exposed at higher temperatures than were realized by the specimen while in the reactor. This is accomplished by introducing the specimen to the induction field, subjecting it to various temperatures for 10 sec. or less. The temperatures selected are not random, but depend on existing or proposed maximum operating central core temperatures. Generally, these range from 600 to 900° F.

Basically the cycling would run as follows. With a continuously running inert atmosphere (helium or argon gas), the fully irradiated specimen would be introduced into the field. Attached to the specimen would be a high-speed recording thermocouple attachment. Power input to the 10-kw. RF generator was rheostatically controlled to control the temperature. The specimen would be brought to an ambient temperature, or the temperature to which the specimen would be exposed under normal operations in the reactor. After a 3 to 5 sec. pe-



Formula for Success

The formulation of a stainless steel alloy requires as much precision as any chemical compound. All the care exercised in the selection of a particular alloy can be nullified by variations in the analysis specified.

During fabrication, for example, slight differences in chromium-nickel: carbon ratios can cause changes in microstructure which lead to early failure.

That's why it is safer to specify J&L Consistent Quality Stainless Steel. J&L leads the industry in melt shop standards for stainless steel—the point where quality starts, **and longer service life begins.**

Plants and Service Centers:
Los Angeles • Kenilworth (N. J.) • Youngstown • Louisville (Ohio) • Indianapolis • Detroit

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STAINLESS
SHEET • STRIP • BAR • WIRE

Jones & Laughlin Steel Corporation • STAINLESS and STRIP DIVISION • Box 4606, Detroit 34

Circle 521 on Page 48-A

3 All New electric

. . . to make

FEATURES:

- Wide band adjustments: 0 to 500% prop. band, 0 to 100 repeats/min. reset, and 0 to 10 min. rate.
- Bumpless transfer even when control output is changing.
- Change proportional band any amount without upsetting process.
- Rate action circuit minimizes overshoot in batch process and during startup.
- Pull-out chassis for servicing without interrupting operation.
- Modular construction simplifies maintenance and stocking.
- Plug-in silicon diode rectifiers for greater reliability.

All three units use the same plug-in components . . . only the control output section is different. Simplifies on-the-job servicing . . . eliminates need for complicated test equipment.

3-mode control units

furnaces perform at their best

***Electr-O-Line* Control Unit**—For electronic position-proportioning control with reset and rate action

***Electr-O-Pulse* Control Unit**—For electronic time-proportioning control with reset and rate action

***Electr-O-Volt* Control Unit**—For electronic current output proportioning control with reset and rate action

One of these units—*Electr-O-Line*, *Electr-O-Pulse* or *Electr-O-Volt*—will deliver the exact kind of temperature control that's best for your furnace.

Plug-in construction is used throughout all three units—including common amplifier and power supply sections. Operator adjustments are exactly alike for all three units. Interchangeability of control output sections simplifies stocking and service problems.

Get complete details on these and other types of furnace controls from your nearby Honeywell field engineer. Call him today . . . he's as near as your phone.

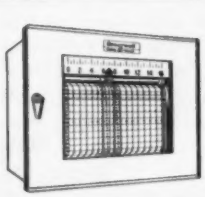
MINNEAPOLIS-HONEYWELL, Wayne and Windrim Avenues, Philadelphia 44, Pa.

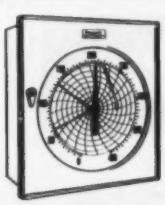
Honeywell

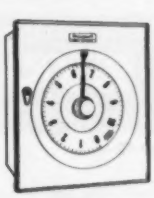
H HONEYWELL *First in Control*

SINCE 1885

75th YEAR — PIONEERING THE FUTURE

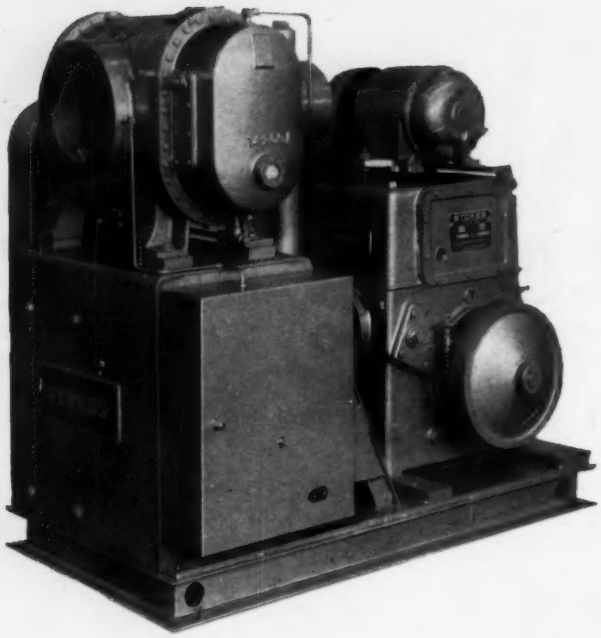






Use *ElectroniK* strip chart, circular chart or circular scale controllers to actuate *Electr-O-Line*, *Electr-O-Pulse* or *Electr-O-Volt* units. They are integrally mounted, simplifying panel cutout and reducing wiring costs.

Circle 522 on Page 48-A



STOKES MECHANICAL BOOSTER PUMPS

Packaged high-speed pumping systems that feature automatic push-button operation

Stokes Mechanical Booster Pumps are streamlined, compact integrated systems that offer the user greater pumping speed per dollar. The unit consists of a coaxial blower first stage, backed by the latest gas-ballasted Microvac rotary vacuum pump. Four models are available . . . Model 1710, with a 1050-cfm rating—Model 1711, rated at 1160 cfm—the 1712, rated at 2900 cfm—and the 1713, rated at 5100 cfm.

Operation of this Stokes system is entirely automatic. When the pressure has been roughed down to 15 mm Hg, a pressure switch actuates the blower unit. There are no complicated switching or valving procedures necessary. All models feature an ultimate blank-off of 0.5 microns and tremendous throughput.

Call your nearest Stokes office, or contact Stokes' Engineering Advisory Service for complete specifications on all models—or application assistance for your own specific process.

Vacuum Equipment Division
F. J. STOKES CORPORATION
5500 Tabor Road, Philadelphia 20, Pa.

STOKES

Circle 554 on Page 48-A

Nuclear Meeting . . .

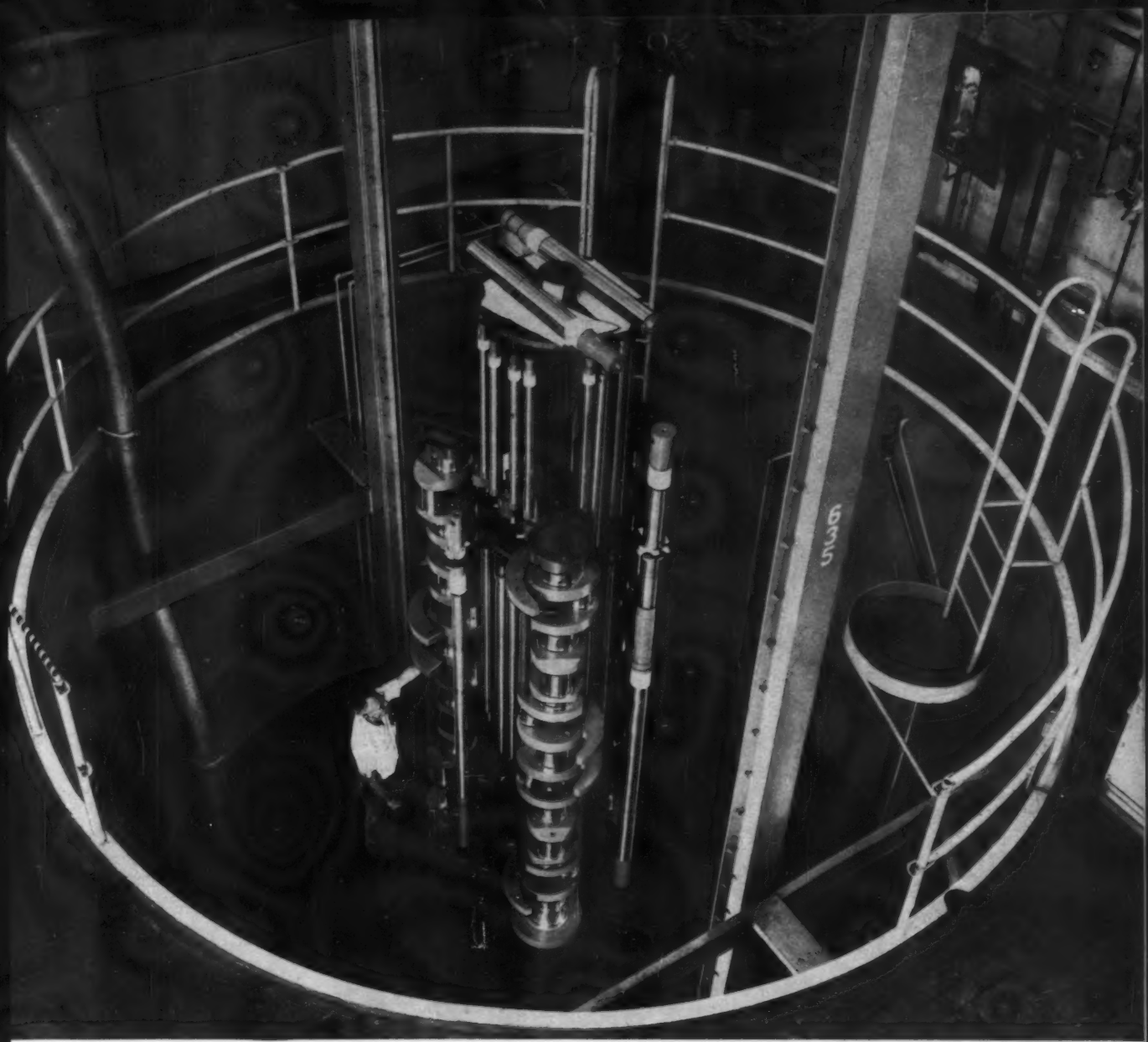
riod of stabilization, the temperature excursion would be put into effect. Hence the cycle would be from the ambient to the transient (or temperature excursion point) and then a rapid quench back to ambient, the cycle period being less than 10 sec. This procedure would be repeated on a multicycle basis with periodic examinations of the specimen to note effects and possible changes.

Ultrasonic Examination

The inadequacy of suitable and more extensive nondestructive testing equipment to be used on irradiated material has long been recognized. Ultrasonic testing goes far toward filling this gap in determining extent of damage due to irradiation exposure. Ultrasonic examination (by remote control) is now being used as a standard operational test on highly irradiated material. Voids, undetectable by visual examination or dimensional survey, can be found with ease. This information is particularly useful when the damage is of a macro level, or the voids are of low magnitude. These gas pockets would very probably be undetectable, in many instances primarily because experience has shown that these defects occur locally.

Moreover, the magnitude of the defect is measurable. Its particular area of occurence is pertinent to the experimenter in that he can associate damage relative to neutron exposure. This is pertinent because actual flux gradients can differ appreciably over short distances.

The in-cell apparatus for remote control ultrasonic inspection consists of a water tank in which the test specimen is mounted. Crystals are hung from a carriage which travels along the top of the tank. Two ⅝-in. diameter, 5-megacycle quartz crystals are used. One transmits the ultrasonic signal, the other receives it. The rectangular test specimen is mounted on a longitudinal edge between the two crystals. A drive mechanism actuates these crystals at 250 cycles per min. in an up and down motion while traversing the specimen length at 9 in. per min. Outside the cell is located a Sperry Reflectoscope, Model UR50E495, an Alden Electrosensitive Helix Recorder, Model 305A, and a control



WHO FORGES THE TOUGH ONES?...
and nitride-hardens them, too?

National Forge does it—with a nitriding installation that is one of the largest and most modern in existence. Now diesel crankshafts, pump eccentrics, compressor pistons and rods, gears, marine couplings, and many other machinery parts are not only *forged* at National, but *nitride-hardened* to add strength and reduce wear. Vertical nitriding furnaces like the one illustrated will accommodate forgings up to 16 feet in length.

National Forge also has its own basic electric melting facilities and produces all the usual types of nitriding steels, including the recently developed 5% nickel, 2% aluminum grade. For further information, write for bulletin NH-1058.

NATIONAL FORGE COMPANY

IRVINE, WARREN COUNTY, PENNSYLVANIA

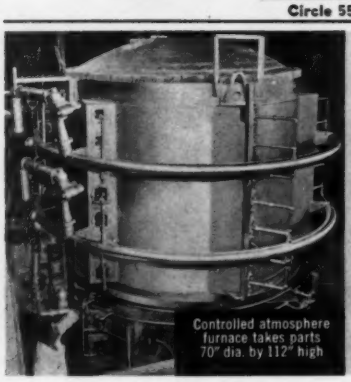
NF 60-01

For more information on "the tough ones," and the machinery that makes them "best"—write for bulletin NFO

Circle 523 on Page 48-A

'PSC' RADIANT TUBES in
Any Design or Dimension
'Light-Weight' Heat-Treat Units for Every Use
PSC fabricated tubes furnish four substantial advantages: (1) Light-wall construction saves furnace time and fuel. (2) Return bends are of same wall thickness as tubes, promoting uniform flow of gas. (3) Smooth dense walls minimize carbon build-up and burn-out. (4) Up to 100% longer life. In any alloy, size or type, including parabolics. Also sheet-alloy heat-treating retorts and covers, boxes, baskets, fixtures, tubes, etc.
PSC
THE PRESSED STEEL CO • Wilkes-Barre, Pa.

Circle 555 on Page 48-A

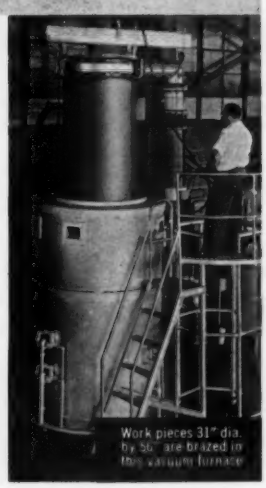


Ask for Special Help When Brazing Stainless

Ask us for help in deciding how to best braze your stainless alloy assemblies. We successfully braze almost every known stainless steel, superalloy, and aluminum or titanium bearing metal.

Ask us to choose the best brazing alloy from the massive array of copper, silver, and nickel base alloys available. We know and use them all.

Ask us for a quotation on doing your stainless brazing or heat processing. Our pencils are sharp and so are the four furnace plants we operate to serve you.



WALL COLMONOY CORPORATION
Stainless Processing Division
19345 John R Street • Detroit 3, Michigan
Wall Colmonoy furnace plants are maintained in Michigan, Pennsylvania, Ohio, and California

Circle 554 on Page 48-A

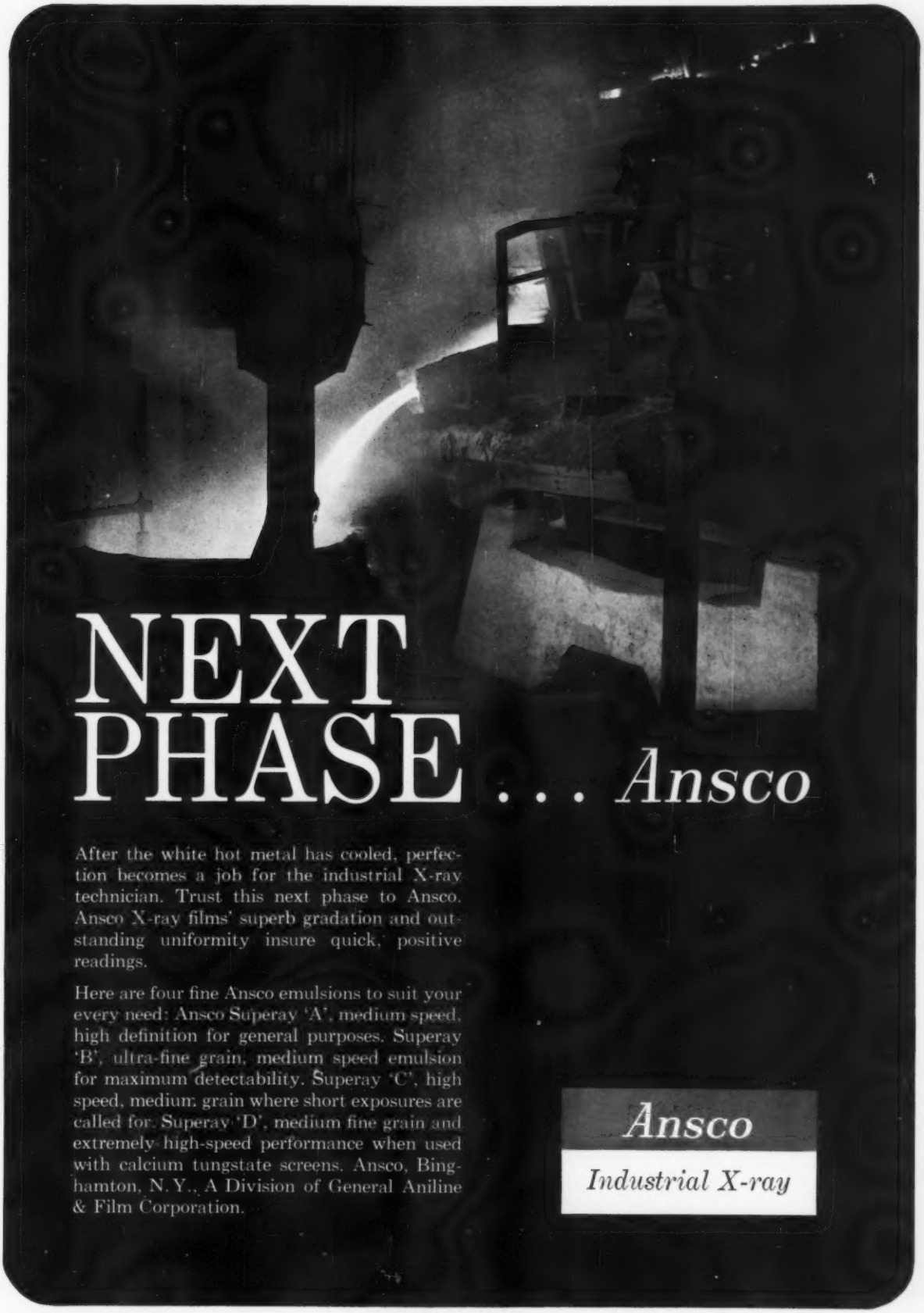
Nuclear Meeting . . .

assembly. The ultrasonic signal, generated by the reflectoscope and transmitted by the crystal, passes through the test specimen and returns to the reflectoscope where it is amplified and fed into the recorder. The recorder is synchronized with the crystal drive mechanism, so that one cycle of the crystals is presented as a single line on the recorder paper. As the chart paper moves through the recorder, a series of closely spaced lines are printed. Their intensity depends on the intensity of the ultrasonic signal passing through the test specimen. Where the signal passing through the test specimen is reduced in strength (such as at edges or at discontinuities), the recorder prints a light intensity line or may not print at all, depending on the sensitivity adjustment and magnitude of the discontinuity. When the crystals have passed along the length of the specimen, a complete picture showing the edges of the specimen and any discontinuities is obtained.

Fabricating Nuclear Alloys

A new method of fabrication of nuclear alloys was discussed. It is comparable to slip casting, a method for casting ceramics and refractory metals. The absence of a pressure application is advantageous in that fabrication of large shapes is possible and stringer formation is practically eliminated. The apparent success of random distribution of UO_2 in a stainless matrix suggests the possibility of this process being applied to other materials such as control rod alloys and poison-bearing fuel elements.

A fabricating process of preparing fuel elements employs the powder metallurgy technique for the compact, and a cast-cladding technique for the cladding. Aside from being economical, the process lends itself to small scale operation suitable to a university laboratory or pilot laboratory level. Complete containment of the powder dispersants aids in preventing contamination of equipment with toxic elements. Losses of fissionable material and other constituents during fabrication is practically eliminated, thus insuring a more accurate control of final alloy composition. F. O. Von Plinsky



NEXT PHASE . . . *Ansco*

After the white hot metal has cooled, perfection becomes a job for the industrial X-ray technician. Trust this next phase to Ansco. Ansco X-ray films' superb gradation and outstanding uniformity insure quick, positive readings.

Here are four fine Ansco emulsions to suit your every need: Ansco Superay 'A', medium speed, high definition for general purposes. Superay 'B', ultra-fine grain, medium speed emulsion for maximum detectability. Superay 'C', high speed, medium grain where short exposures are called for. Superay 'D', medium fine grain and extremely high-speed performance when used with calcium tungstate screens. Ansco, Binghamton, N.Y., A Division of General Aniline & Film Corporation.

Ansco

Industrial X-ray

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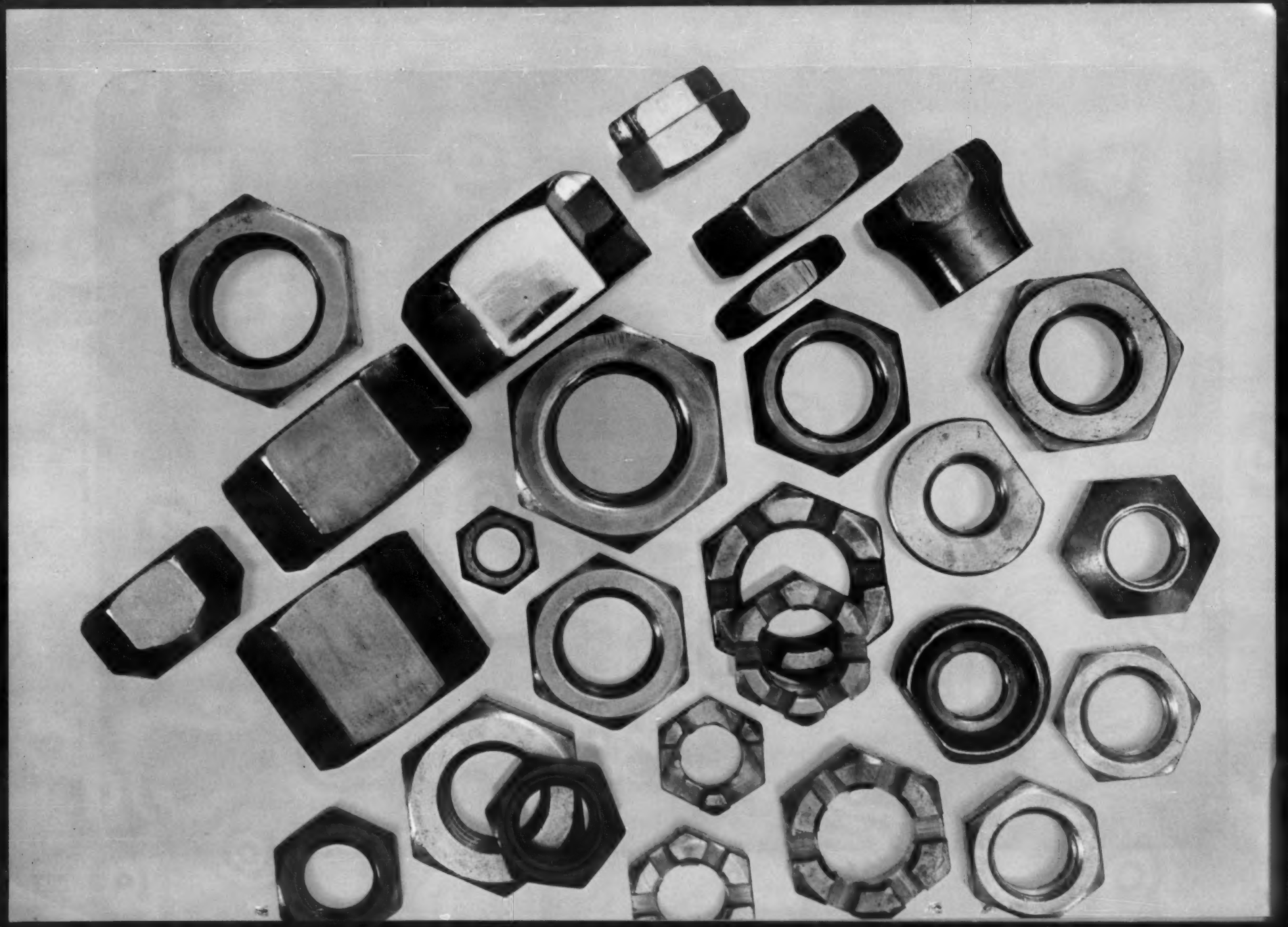

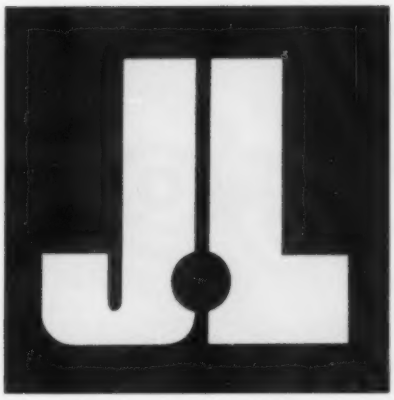

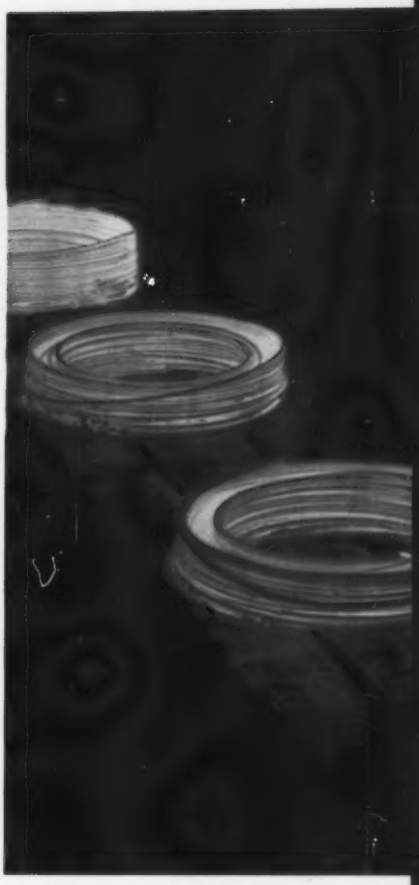

Pittsburgh Works bar mill—where scrapless nut quality hot rolled steel bars are tailor-made for any nut application.

We may not know your production equipment
We may not know your product application
We may not know anything about your specific requirements

. . . but we want to

and, we do know all about scrapless nut quality hot rolled steel bars

and the techniques in metallurgy and in nut-forming that result in smoother production runs, fewer rejects and less waste. We know how to achieve the precise balance and uniformity in steel bars to provide you with the best combination of nut-forming properties. We can assure optimum metal flow characteristics and shear strength so that the steel will cold work easily and will not crack. We control steel to low rates of strain hardening so that large volumes of metal can be upset without annealing. Most important, we regard your nut-forming problems as our major challenge. . . .

and when given an opportunity to talk to you about your specific operation, we'll know how to develop exactly the right steel to meet your needs. We invite your inquiry. Please write . . .

Jones & Laughlin Steel Corporation

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Everything new but the shape

Ever since man discovered the wheel, he has been working at new ways to use it. The latest use of the wheel is in the jet turbine. These turbine wheels and compressor wheels, forged in massive closed dies from materials unknown a few years ago, make possible the outstanding performance records of our American engines.

Helping wheels turn—on the ground—on the sea—in space—is all part of Wyman-Gordon's business. Where performance depends upon stamina, there is no substitute for a forging—and in a forging there is no substitute for Wyman-Gordon experience, quality and dependability.

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FORGINGS

of Aluminum Magnesium Steel Titanium . . . and Beryllium Molybdenum Columbium and other uncommon materials

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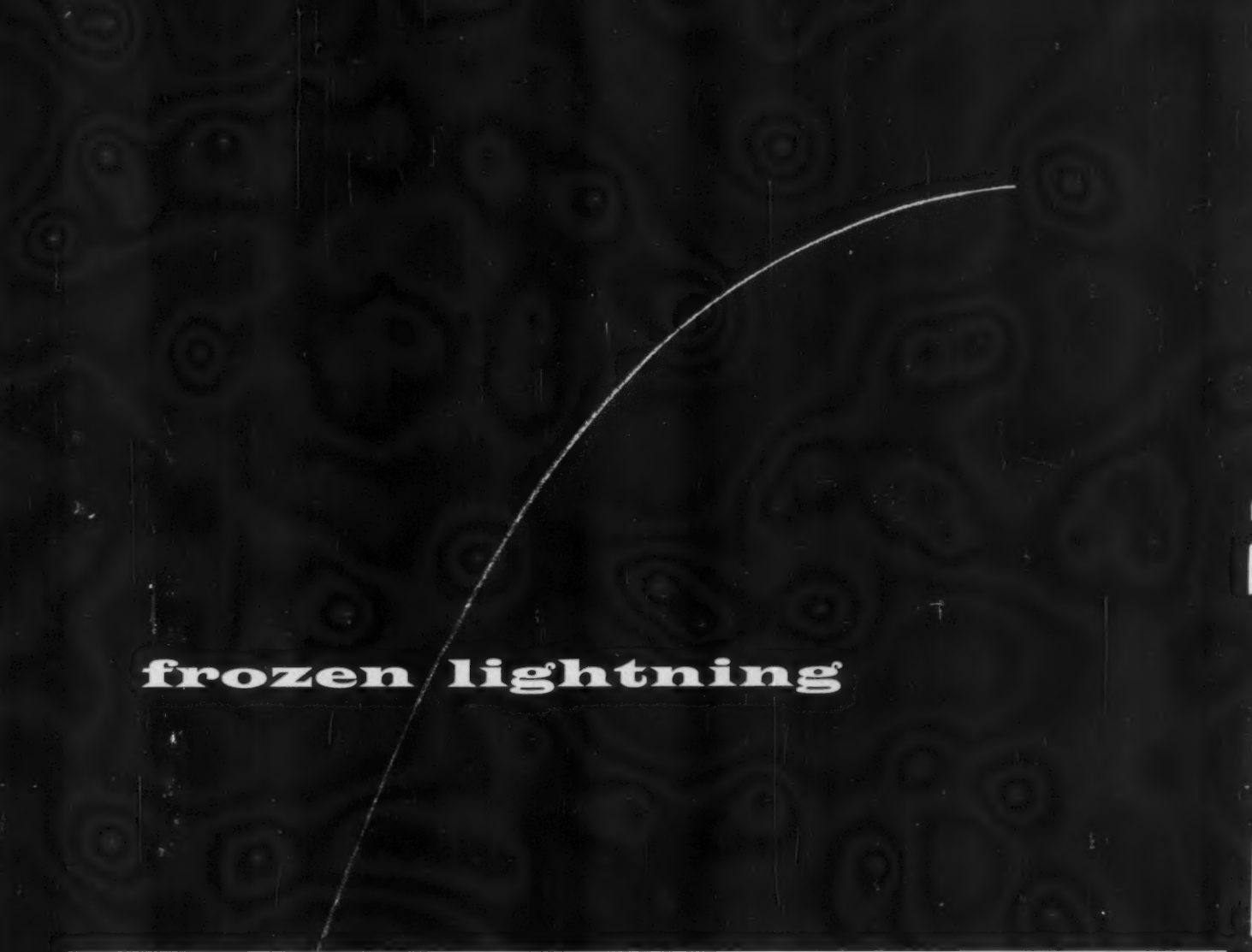
Circle 525 on Page 48-A



That's what the Germans call the stratosphere trails of high altitude rockets. Soon, Mach 4-5 aircraft will be cutting frozen lightning trails across our own skies. Structural parts of hypersonic aircraft and missiles must function perfectly at temperatures too high for ordinary alloys.

The answer lies in predictable performance Carpenter alloys made by the exclusive Mel-Trol®, VacuMeltrol®, and Consumet® melting processes. Engine builders find them ideal for many critical parts. Forge shops report improved forgeability resulting in better finishes requiring far less machining . . . fewer rejects.

For the whole story about Carpenter predictable performance high temperature alloys, call your local Carpenter Representative or write: The Carpenter Steel Company, 133 W. Bern Street, Reading, Pa.

Carpenter steel

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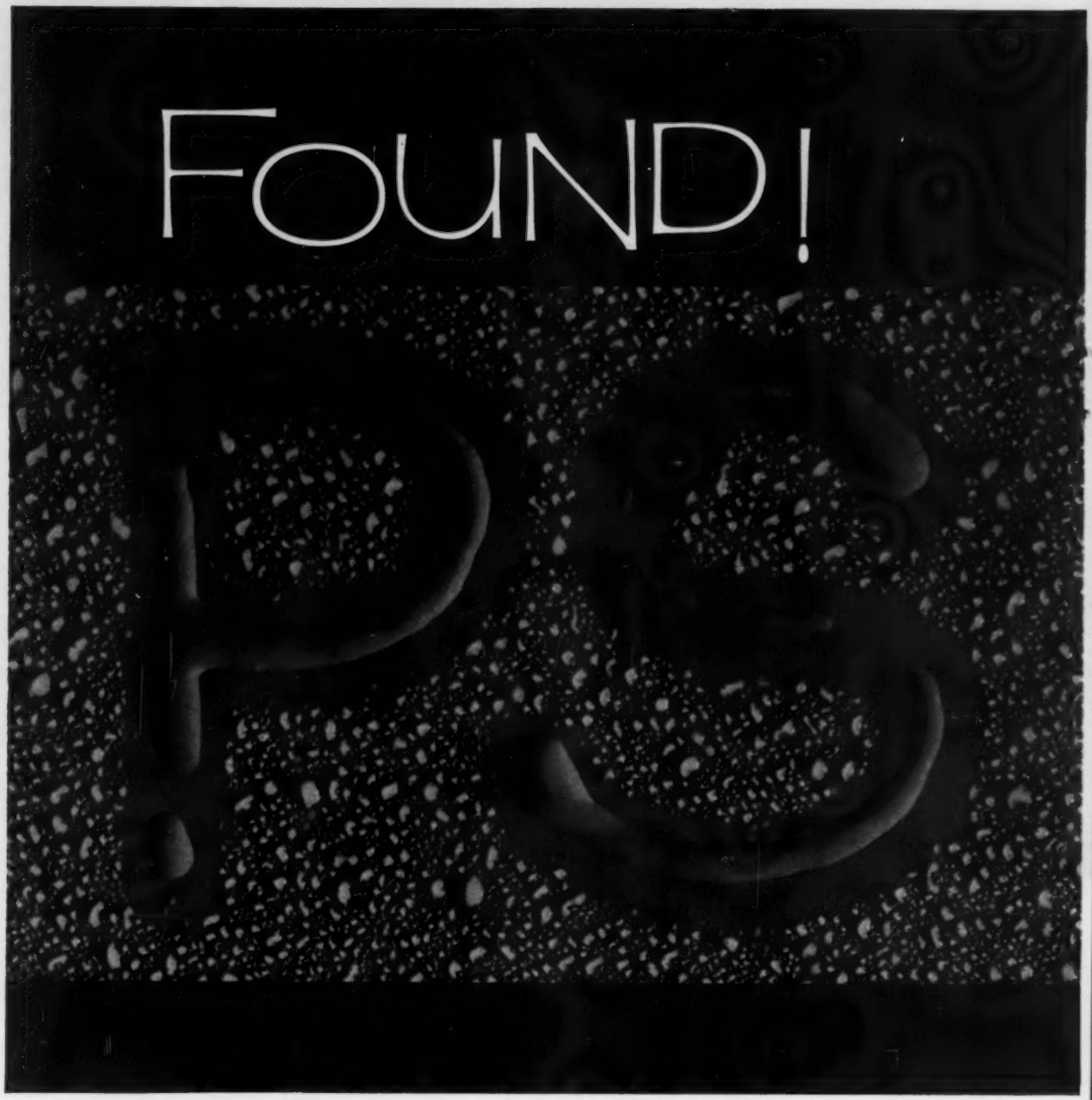
Webb Wire Division, New Brunswick, N.J.
Carpenter Steel of New England, Inc., Bridgeport, Conn.

Circle 573 on Page 48-A



A WAY TO DEGREASE MORE PARTS PER DOLLAR OF CLEANING COST

What makes the big difference in vapor-degreasing cost?

It's not what you pay for solvent. It's how long your solvent keeps working between degreaser cleanouts.

WHAT'S PSP? It means "permanent staying power." It's what you get with Nialk TRICHLOR. The stabilizer in this solvent doesn't wear out. You don't need to add fresh stabilizer when you degrease with Nialk TRICHLOR. You don't have to check the pH. The stabilizer stays with the solvent and keeps on protecting it. In the bath. In the vapor. Even after repeated distillation.

WHY IS PSP IMPORTANT? Users report substantial savings with this better, more stable trichlorethylene. Degreasers run without shutdown for weeks—even months longer between cleanouts, in many cases. Rejects are down sharply. Less solvent is needed, because less goes down the drain in unnecessary cleanouts.

To start saving in your plant—soon—see your Nialk TRICHLOR distributor. He can show you why your best buy is the solvent that doesn't wear out prematurely. Call him today.

NEW 36-PAGE BULLETIN explains fully how you get more and better vapor degreasing for the money with Nialk TRICHLOR. Shows basic types of vapor degreasers. Discusses cycles, operating procedures, stabilizers, causes of solvent contamination, solvent recovery, trouble shooting. Ask your distributor for a copy or write us.

Nialk® Trichlor, a product of

HOOKER CHEMICAL CORPORATION

402 Union Street, Niagara Falls, N. Y.

HOOKER CHEMICALS PLASTICS

Sales Offices: Buffalo Chicago Detroit Los Angeles New York Niagara Falls Philadelphia Tacoma Worcester, Mass.
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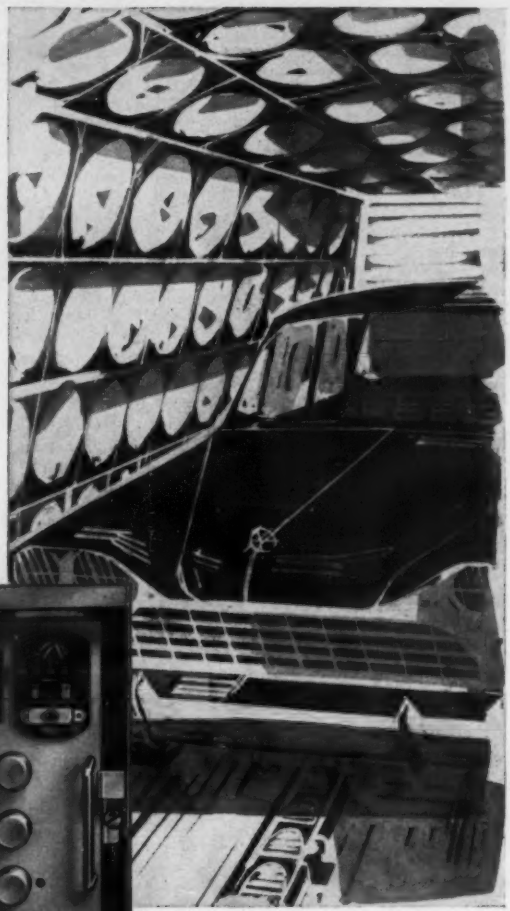
Circle 574 on Page 48-A

from Honeywell... ANOTHER DIAMOND JUBILEE PRODUCT

Honeywell is first with the only fail-safe flame safeguard!

New maximum-safety, self-checking relay prevents losses due to burner safeguard failure and resulting explosions.



The Honeywell Protectoglo* Relay offers you the most fail-safe protection yet devised for industrial burner safeguards—truly an important break-through in the art of flame safeguarding! Never before has a flame safeguard offered you such low-cost assurance against explosions and downtime. Compared to the Honeywell R4075, all other continuous process flame safeguards are obsolete!

In other flame safeguards, safe-start, self-checking networks operate *only during start up or recycling*. The new R4075 unit operates constantly. It will cause an immediate safety shutdown and sound an alarm if the sensing signal, amplifier or related circuitry fails *at any time* while the burners are operating or during start ups or shutdowns. This same self-checking circuit checks all components of the Protectoglo system including the flame rod once *every* second. You get maximum protection, not only on safeguard systems for constantly burning gas burners using flame rods, but also on gas- or oil-fired systems using Ultra-Vision flame detectors. For information on how the Honeywell R4075 can help your industry, call your nearest Honeywell office; or write: Minneapolis-Honeywell, Dept. MP-2-30, Minneapolis 8, Minnesota.

*Trademark

Honeywell

75th YEAR PIONEERING THE FUTURE

First in Control SINCE 1885

Circle 575 on Page 48-A

CARBORUNDUM'S TECHNICAL INFORMATION ON SPECIAL REFRACTORIES **Data sheet**

Comparative tests help determine

HOT STRENGTH

Studies of hot strength — or the ability to stand up under load at elevated temperatures—are a primary requirement in the selection and application of practically all refractories. The need for accurate data becomes all the more important as operations move to higher and higher temperatures, or where long periods of soaking heats are involved.

Information available from Carborundum includes compressive load tests, covering short duration and sustained periods, to indicate load-carrying capacity. Transverse load tests also provide valuable information — particularly, for applications where large spans of refractory shapes are unsupported or must carry a heavy furnace charge.

Engineering assistance can be given in evaluating the various factors affecting operation and in applying Carborundum's refractories to your job. Please feel free to ask any questions that may occur to you.

SUSTAINED LOAD TESTS

	Load, Psi.	Deformation After 100 Hr., % Temperature, Deg. F. 2192	2462	2732
Fireclay	6.25	0.30	3.9	—
	12.5	0.23	4.3	—
	25	0.32	11.3	—
	50	0.46	over 10.3	—
Semi-silica	6.25	—	1.19	—
	12.5	—	3.14	—
	25	—	5.03	—
	50	1.19	—	—
Silica	6.25	—	—	—
	12.5	—	—	Nil
	25	—	—	0.13
	50	—	—	0.25
High-alumina-fireclay	6.25	—	2.8	—
	12.5	—	2.4	—
	25	0.87	7.7	—
	50	1.30	9.9	—
Alfrax® "K" brick	6.25	—	+0.20	2.51
	12.5	—	+0.04	3.73
	25	—	0.25	8.68
	50	—	1.08	10.58
Monofrax® H brick	6.25	—	—	—
	12.5	—	—	—
	25	—	—	—
	50	—	—	0.36
Carbofrax® brick	6.25	—	—	0.40
	12.5	—	—	0.40
	25	—	—	0.58
	50	—	—	0.78

Comparison of hot strength of various refractories held at 3128 F for 1½ hrs under load of 25 psi shows CARBOFRAX® silicon carbide brick undeformed (extreme left) and MULLFRAX® electric furnace mullite brick (second from left) with less than 1.4% contraction. Other samples shown are commonly-used refractories in various stages of deformation. One on the right failed at 3002F.

HIGH TEMPERATURE, SHORT DURATION LOAD TESTS

Refractory	Max. Expan. at Temp. °F	Start Rapid Contr. °F	Hold Temp. Max. °F	Hold Temp. Aver. °F	% Linear Cold Contr.	Cold Length
Mullite brick	2561-2795	2867	3137	3128	14.3	7.75"
Mullfrax® W brick	2552-2768	None	3128	3119	1.31	8.943"
Carbofrax® A brick	2534-2714	3092	3146	3137	0.78	8.915"
Chrome magnesia brick	2597-2741	2975	Crushed at 3002		—	"Sheared"
Fireclay brick	2642-2660	2732	Crushed at 3002		—	6.75"
Fireclay brick	2462	2561	Crushed at 2993		—	6.6"
High alumina brick	2561-2624	2642	Squashed at 3011		—	6.7"
Silica brick	2795-2903	None	Crushed sharply at 2948		—	"Sheared"
Magnesia brick	2327	2507	Crushed at 2552		—	"Sheared"

Write today for your free copy of "Super Refractories by Carborundum." The address: Dept. M-20, Refractories Division, Perth Amboy, New Jersey.

For engineered refractories, count on **CARBORUNDUM®**

Circle 590 on Page 4B-A

Greater visibility, trimmer lines for the new CHEVROLET, thanks to GAS! This is Libbey-Owens-Ford, where the new panoramic windshields are made for your beautiful new Chevrolet.

The forming of the curved glass is done in a limited temperature range at which glass can be bent without distortion. The production process challenged heat process engineers to design new automatic equipment capable of mass producing these large precision glass pieces.

LOF engineers, working with General Motors, discovered that Gas could produce the proper time-temperature cycle demanded by this process...efficiently, quickly, reliably.

The flat glass is conveyed under radiant Gas burners which bring the glass quickly up to bending temperature and allow the shaping of windshields, with reproducible uniformity, at high production rates.

The production of the Vista Panoramic windshield is another example of the contributions modern Gas equipment is making to American manufacturing. If your operation includes precise process heating, call your Gas company's industrial specialist and see how you can improve production with modern Gas equipment. AMERICAN GAS ASSOCIATION

FOR PROCESS HEATING GAS IS GOOD BUSINESS

Circle 584 on Page 48-A

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That's not all these versatile alloys will do for wrought stainless and heat-resisting steels. They minimize heat-checking of castings, reduce conditioning operations, and further lower costs by cutting rejections. Grainal acts as an intensifier for hardening boron-containing constructional steels and helps protect both low- and high-alloy steels against internal and external rupturing in many hot-forming operations. And it promotes uniformity from heat to heat.

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Producers of alloys, metals and chemicals

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Circle 576 on Page 48-A

Colloidal Graphite dispersions

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- Forging compound
- High temperature lubricant
- Extruding compound
- Dry film lubricant
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GRAPHITE PRODUCTS CORPORATION
BROOKFIELD, OHIO

Circle 591 on Page 48-A

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Electric TUBE FURNACE

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- Horizontal or vertical models—in Cabinet or Trunion mounted.
- Selection of tube lengths and diameters.
- Either hollow silicon carbide (tubular) water cooled element, or ceramic tube surrounded by air-cooled silicon carbide elements.
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Columbus 12, Ohio

PERENY EQUIPMENT COLUMBUS O.

Circle 592 on Page 48-A

High Temperature Ceramics

Leco®

Use up to 2700°C

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Consider this list of LECO pure oxide ceramic materials (no binder to lower melting point), their chemical composition and top usable temperature in an oxidizing atmosphere.

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Spinel	$MgO.Al_2O_3$	1900°C
Thoria	ThO_2	2700°C
Zircon	$ZrO_2.SiO_2$	1870°C
Zirconia	ZrO_2	2500°C

For further information write:

LABORATORY EQUIPMENT CORP.
5061 Hilltop Road, St. Joseph, Michigan

Circle 593 on Page 48-A

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Circle 594 on Page 48-A

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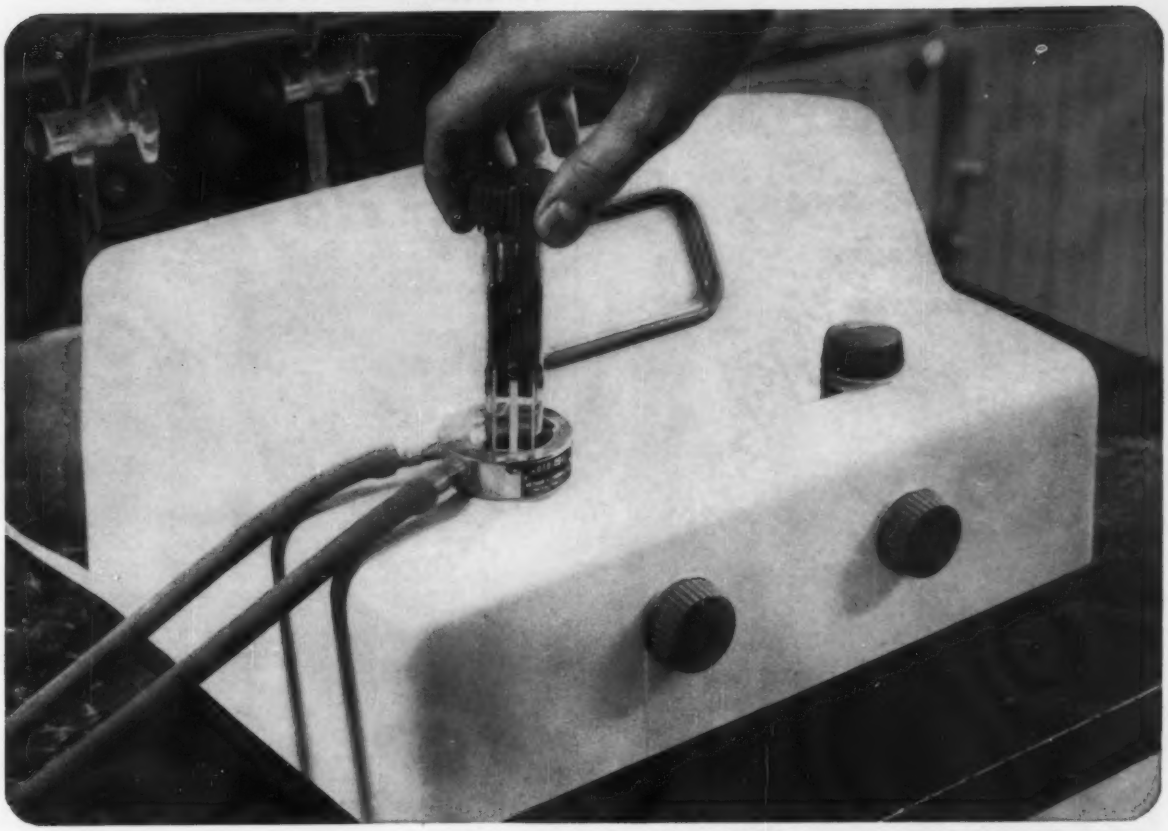

COLORIMETER (inherently extremely accurate) determines percentages of molybdenum, tungsten, cobalt and manganese in A-L tool steel to insure consistent, high quality.

Colorimeter measures exact chemical composition of Allegheny Ludlum tool steel melts

Accurate adjustment of alloys guarantees uniform heat treatment, predictable dimensional changes, reduced grinding, standardized machining operations.

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Allegheny Ludlum stocks a complete line of tool steel sizes and grades. Call your nearest A-L representative; you'll get quick service and counsel on such problems as heat treating, machining, grade selection, etc. Or write for A-L's publication list which gives full data on the more than 125 technical publications offered. They'll make your job easier.

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every grade of tool steel... every help in using it

Circle 577 on Page 48-A

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Circle 595 on Page 48-A

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OF HARROP CERAMIC SERVICE CO.
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Circle 596 on Page 48-A

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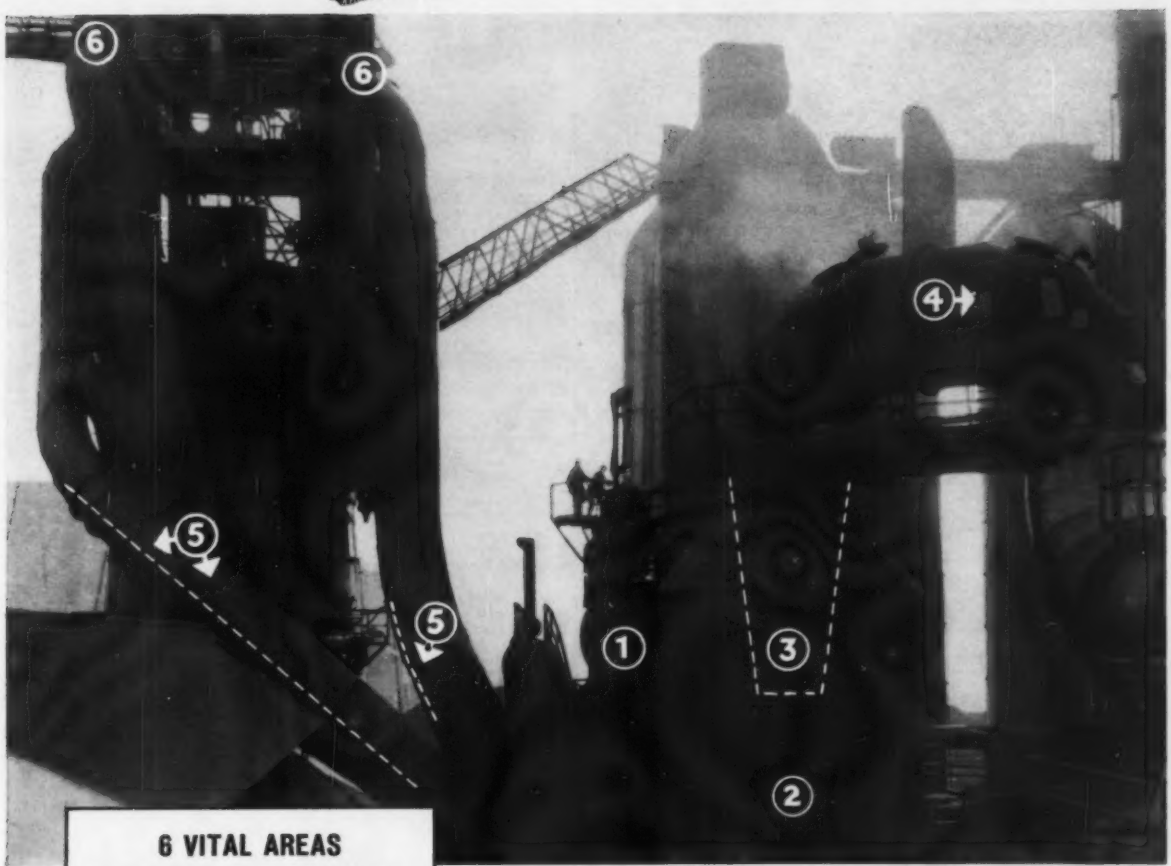
Serving American industry nation-wide with over 10,000 stock items of good tool steel

Product of Skilled American Workmen

Circle 597 on Page 48-A

Industrial concretes protect blast furnace "hot spots"



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gun-applied industrial concretes in blast furnace downcomers and dust separator, National Tube Div., U. S. Steel, McKeesport, Pa.

1. **Dust catcher,** spot repairs to brick lining.
2. **Dust separator** shell, complete lining.
3. **Inner cone,** complete lining.
4. **Elbows and piping,** lined for 65 lineal feet.
5. **Downcomers,** gunited for 120° arc in pipe bottom.
6. **Connections between uptakes and downcomers,** spot-repaired (two other connections gunited not shown).

For repairs or new installation, industrial concrete linings in blast furnace equipment solve many abrasion, erosion and heat problems. In addition, these monolithic concrete linings provide insulation. Made with LUMNITE calcium-aluminate cement and suitable aggregates, concrete linings are easy and economical to place – by guniting, casting or troweling. Unit downtime is reduced because concrete reaches service strength in 24 hours. For greater convenience, castables containing LUMNITE cement are available from leading manufacturers of refractories. These are packaged mixtures, ready to use by adding only water. For more information, write Universal Atlas Cement, 100 Park Avenue, New York 17, New York.

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Circle 583 on Page 48-A

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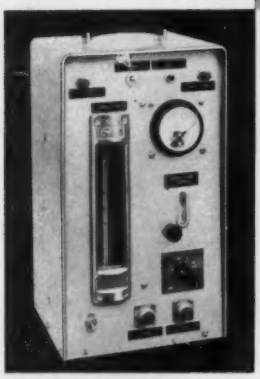

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Useful applications:

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All Model W analyzers include flow indicators

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Circle 579 on Page 48-A

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- for shrink fits
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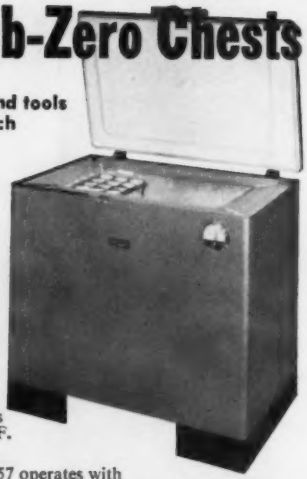

Model RSZ503 Rivet Cooler (shown) equipped with 90 rivet canisters, temperatures to –30° F. 110V, 60 cycle, single phase.

Model SZH153 with temperatures to –95° F. 110V; 60 cycle, single phase.

Model SZH653, larger capacity, temperatures to –85° F. 110V, 60 cycle, single phase.

Model SZHC657. Same capacity as SZH653 but attains temperature as low as –140° F. 220V, 60 cycle, single phase.

Refrigeration: Model SZHC657 operates with 3 Tecumseh hermetic compressors in a two system cascade. Other Sub-Zeros use 2 hermetics in a two stage system. Rivet Cooler operates with single hermetic unit. All models equipped with efficient fan-cooled condensers — no liquid coolant required. *Write Today for Full Specifications and Prices.*

Description	Model	Cu.Ft.	Temp. Range		Outside Dim.			Inside Dim.		
			Rm. 70°	Rm. 110°	L	W	H	L	W	H
Sub-Zero	SZH153	1.5	–95° F.	–85° F.	42"	28"	42¾"	23"	9"	12½"
Sub-Zero	SZH653	6.5	–85° F.	–75° F.	60"	28"	42¾"	47"	15"	16"
Sub-Zero	SZHC657	6.5	–140° F.	–125° F.	60"	28"	42¾"	47"	15"	16"
Rivet Cooler	RSZ503	5.0	–30° F.	–20° F.	42"	28"	41"	30"	16"	18"

REVCO, Inc.
Setting Trends in Refrigeration since 1938 — Deerfield, Michigan

Circle 580 on Page 48-A

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designed and built for individual product and process requirements

batch and conveyor types up to 1000° F

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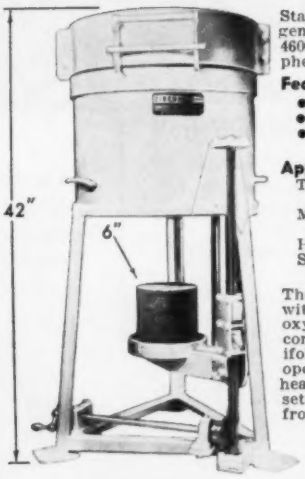
Over 60 years of service

Circle 581 on Page 48-A

HOTPOT

LABORATORY FURNACE OVER 4600°



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Circle 582 on Page 48-A

NOW, FROM RIVERSIDE-ALLOY...

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Circle 578 on Page 48-A

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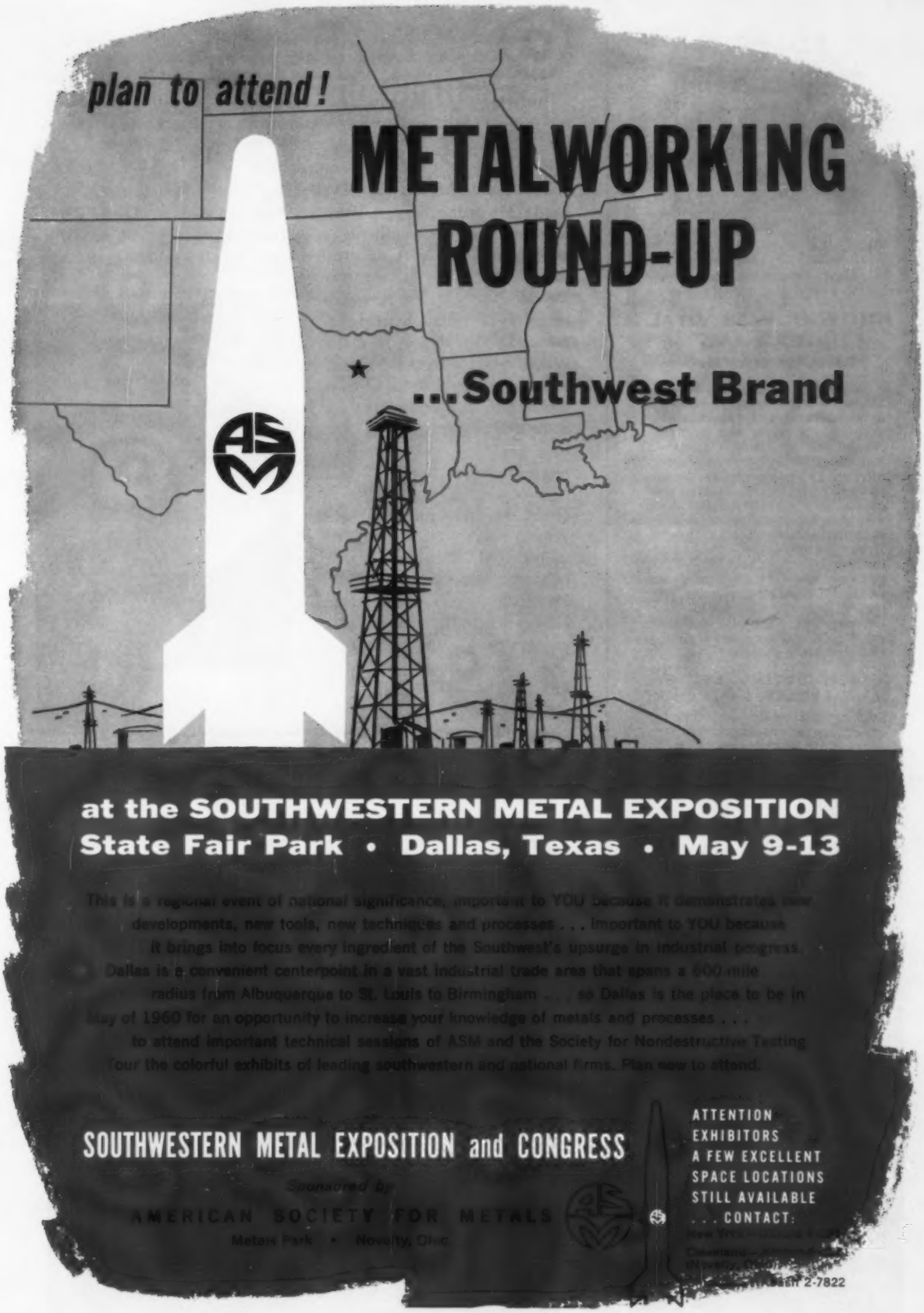
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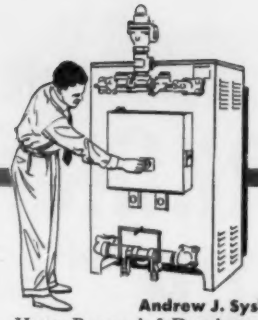

Andrew J. Syska,
Hayes Research & Development Engineer Reports . . .

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BEHIND THE BYLINES

While working on the development of a new gas dryer using Linde Molecular Sieves, Herbert Westeren became familiar with many of the new synthetic crystalline compound's characteristics and capabilities as an adsorptive agent in atmosphere generators; the result is his informative article on p. 75. Assistant director of research at C. I. Hayes in Providence, R. I., he is concerned with the development and application of new techniques and equipment for industrial heat treating and for generation of protective atmospheres.

After serving in the Merchant Marine during World War II (he holds an unlimited steam and diesel engineer's license), he returned to C. I. Hayes as a foreman, and in 1955 joined the research department where he has helped design and develop such equipment as the "Molecu-Dryer."

Whenever possible, he likes to relax with his family, following closely his son's Cub Scout activities, boating on Narragansett Bay with his daughter, gardening a little, and—when time allows—taking short automobile trips.

M. L. Samuels, author of the article on hydroforged pipe (p. 69), has spent many years making a diligent study of solidification mechanism, microstructures, and the relationships between microstructures and various mechanical properties. For some years now, centrifugal casting has been his primary concern and he has ini-

tiated several types of centrifugally cast dual metal products. In the photo below he is examining a seamless dual or bimetal pipe, consisting of a low-alloy steel outer layer and a Type 304 stainless inner layer, hot extruded from a dual metal centrifugal casting similar to the large ring shown flat on the table.

Mr. Samuels spends his off-hours tree farming—he's a member of the Forest Farmers Assoc. and his interests extend to related fields — timber, soil and wild-life conservation. He has also been a member of A.S.M. for nearly 25 years.

J. A. Houck, D. N. Williams and R. I. Jaffee (below), all nonferrous physical metallurgists at Battelle Memorial Institute, teamed up on the research that led to a new class of lead-base dispersion alloys (see their article on p. 79). The new concept, which grew out of work in the solid-liquid field, is an extension of their previous studies on dispersion strengthening of many conventional metals.

Dr. Jaffee, chief of the nonferrous physical metallurgy division, has had a prominent part in the application of new concepts in metallurgy to the tonnage nonferrous metals as well as working with less common metals. He took part in the development of many titanium alloys and guided the research that revealed the significance of hydrogen in titanium embrittlement. Currently, he and his colleagues are carrying out studies on columbium, tungsten, molybdenum, zirconium and other refractory metals.

Dean Williams joined Battelle five years ago and his research work has included alloy development of titanium and refractory metals, studies on titanium embrittlement, and development of dispersion alloys. Jerry Houck has been associated with the development of titanium and refractory alloys and has participated in other nonferrous studies.

The two metallurgists pictured on p. 226, K. T. Ziehlke and W. S. Dritt, are two-thirds of the three-man team responsible for the article on heat treating electroless nickel coatings (p. 84); the other author, C. H. Mahoney, was on vacation when the photo was snapped. All three are members of the metallurgy department in the Oak Ridge Gaseous Diffusion Plant, operated by Union Carbide Nuclear Co. Mr. Mahoney, who joined Union Carbide in 1948, is superintendent of the department and has a varied background in metallurgy with emphasis on light metals and foundry operations. Mr. Ziehlke and Mr. Dritt joined the organization in

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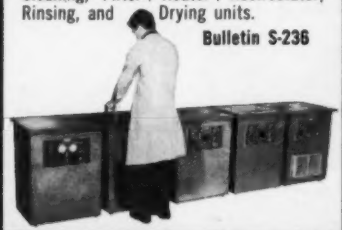

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Behind the Bylines . . .

1950 and are supervisor of metallurgical development and metallography and supervisor of plant equipment problems, respectively.

Mr. Ziehlke's spare time centers on his family (he has four children, ranging in age from two months to seven years) but he also finds time out for various aspects of nature study, including astronomy, minerology, botany and tropical fish. Mr. Dritt is another family man (he too has four children) and is currently

expanding and remodeling his government-built house. Photography, anthropology, civil defense and tinkering with hi-fi are some of his side interests. A native of Kentucky, Mr. Mahoney's civic interests include the Rotary Club and a directorship in the Oak Ridge Boys' Club. As a true Kentuckian, he is generally regarded as an authority on thoroughbred horses and fine tobacco.

Philip C. Rosenthal, one of the authors of the article on how boron affects corrosion of Type 304 stainless, has been a professor of metallurgy at the University of Wisconsin since 1945, serving as chairman of the department for the past four years. Before that time, he spent a total of six and a half years at Battelle Memorial Institute (where he worked in process metallurgy under Clarence Lorig), with four years as instructor at Wisconsin sandwiched in between. His current metallurgical interests are in applications of internal friction measurements to physical metallurgy problems, and grain boundary degredation.

In addition to serving as chairman of the Milwaukee Chapter he is on the Board of Directors of the A.F.S. Wisconsin Chapter.

For hobbies he likes to think about fly fishing and do some fly tying when time is available. During the winter, an occasional ice fishing excursion on nearby Lake Mendota is used as an excuse to get some exercise.

W. A. Black's primary interests are nondestructive testing, welding and automatic control – interests in strong evidence in his article for *Metal Progress* on nondestructive testing in a steel mill (p. 104). He joined Republic Steel Corp. 30 years ago and now is assistant director of research in charge of the electromechanical research center in Cleveland. Other interests include the volunteer fire department, the school board (he has been president for many years), and farming, specializing in maple syrup.

One of H. W. Parker's first jobs when he joined IBM three years ago was to help plan the new heat treating and plating facilities in Rochester, Minn. One of the problems confronting the planners was the uneconomic disposal of waste water from processing operations. How IBM effectively reduced costs in rinsing operations is related by Mr. Parker in his article on p. 82. Joining IBM Rochester as an advisory engineer in the materials laboratory (with a background of 20 years in metallurgy), he serves as a consultant for materials selection, heat treating and finishing problems.

A well-founded background in brazing is the basis for R. R. Ruppender's article on high temperature brazing experiments (p. 95). A manufacturing engineer and brazing specialist in the production engine department of General Electric Co., Cincinnati Ohio, his work has covered such areas as designing and building a vacuum brazing furnace, developing a process for brazing the rocket thrust chambers of the Vega space vehicle, and writing a 270-page manual on high-temperature brazing applications. Before coming to G. E., he was associated with Ferrotherm Co. in Cleveland and helped establish a new division for manufacturing brazed aircraft components.

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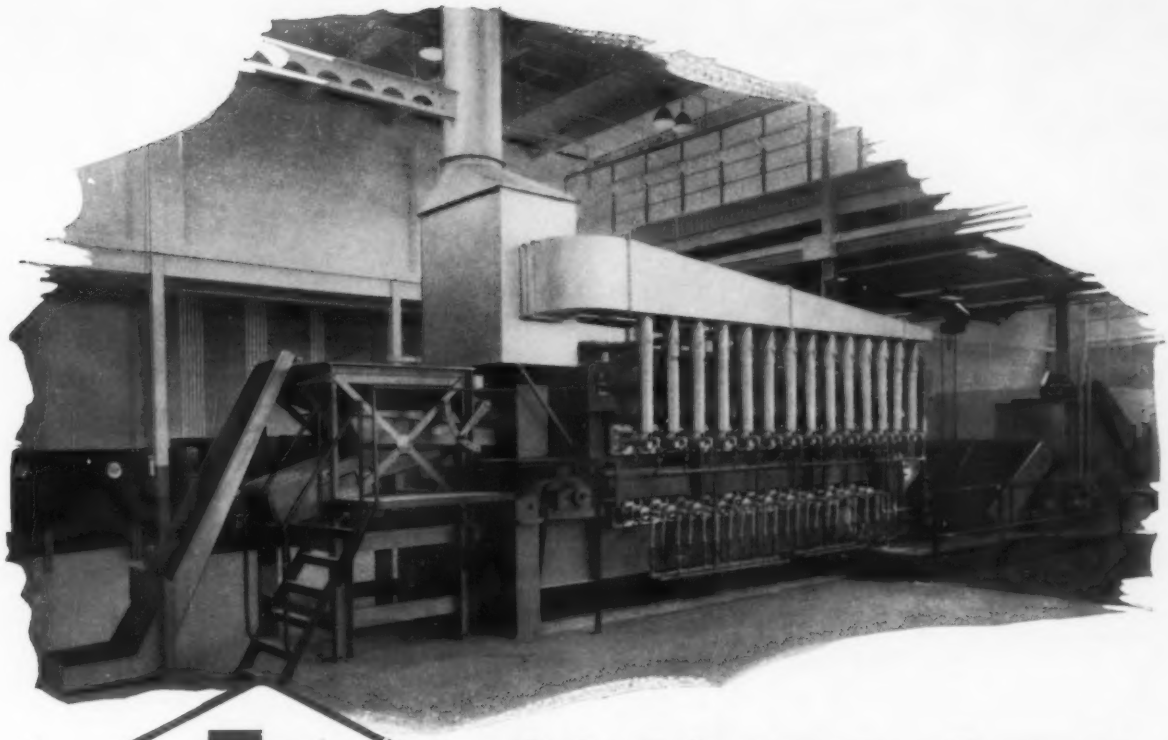

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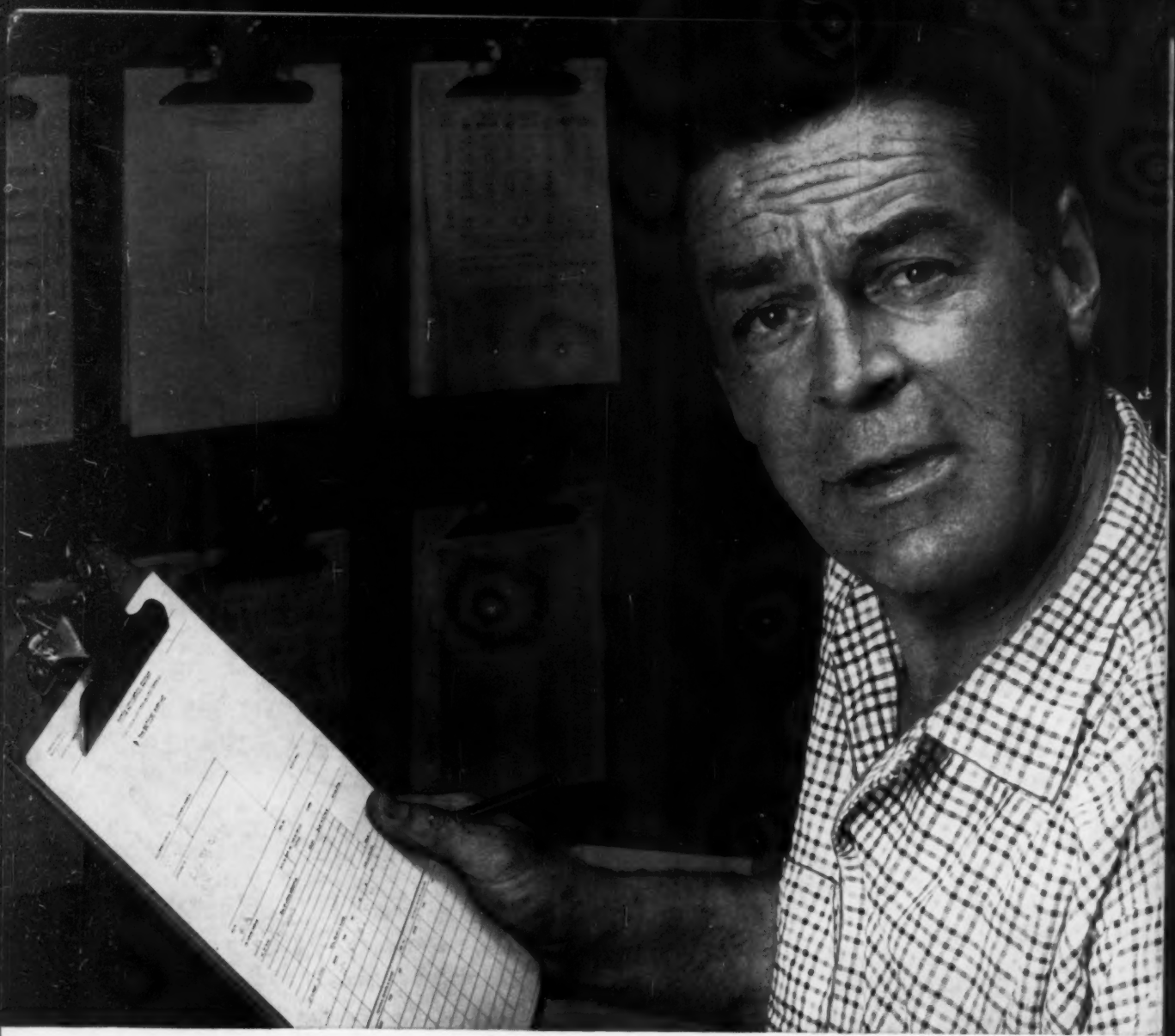

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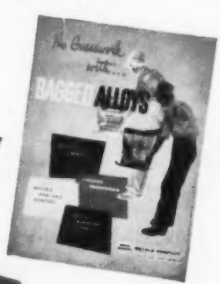

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